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Comments by Clark County, Nevada

U.S. Department of Energy's Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada

Prepared by
Clark County Department of Comprehensive Planning
Nuclear Waste Division
25 February 2000

EIS001888

BRUCE L. WOODBURY
Chairman

Board of County Commissioners

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February 25, 2000

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Office of Civilian Radioactive Waste Management
U.S. Department of Energy
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North Las Vegas, Nevada 89036-0307

Clark County, Nevada Comments on the Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada

Dear Ms. Dixon:

Attached are comments by Clark County, Nevada to the *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (DEIS)*. The comments are the culmination of an extensive review of the DEIS by staff from the Department of Comprehensive Planning, Nuclear Waste Division, supported by outside expertise from other County departments and organizations, and consultants. Clark County also received considerable input from citizens, from nineteen Clark County Town Advisory Boards and Citizen Councils, as well as the incorporated cities, other citizens and advisory committees, and private organizations.

Clark County has, of course, been an active participant since 1983 in monitoring the high-level nuclear waste program. In 1988, Clark County was designated as an "affected unit of local government," under provisions of the Nuclear Waste Policy Act of 1987, in full recognition by DOE that impacts could occur to our citizens and community from activities associated with the Yucca Mountain Program. The concern about potential impacts was manifested in the Board approval of resolutions opposing the siting of a repository in Southern Nevada on January 8, 1985 and April 5, 1988.

1 As the attached comments will fully attest, the Board of Commissioners of Clark County has considerable substantive concerns with the Yucca Mountain DEIS. The deficiencies range from a lack of adherence to the spirit and principles of the National Environmental Policy Act (NEPA) to, specifically, an insufficiency in analysis of potentially significant Clark County impact areas including adverse affects on public health and safety and tourism, among others.

2 The avoidance of these important Clark County issues in the DEIS is especially perplexing. For almost two decades Clark County has interacted closely with DOE to ensure that the agency was aware of the many issues and concerns that Clark County has had with a project of this scope and controversy. Clark County staff has provided substantial evidence over the years that certain aspects of the project, notably associated with the transportation of the nuclear waste, could have, among other potential impacts, substantial negative consequences to Clark County's tourist-based economy. It is difficult, therefore, to understand why these issues were virtually ignored in the DEIS.

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3 The Board strongly recommends that the substantial deficiencies in the DEIS be corrected. Of particular
concern is the need to perform more substantive analyses of the important transportation issues that could
affect a large segment of Clark County's citizenry. Comparative analyses between mode and routing
4 alternatives should be provided to determine potential impacts. There is also the need to consider a host
of other community issues, including potential impacts to Clark County's competitive tourism industry.

To further emphasize the magnitude of our concerns, I have attached a resolution, approved unanimously by the Board on February 15, 2000, urging the Department of Energy (DOE) to either prepare a new DEIS or a supplemental one correcting the deficiencies noted in our comments.

5 The Board greatly appreciates DOE's consideration of Clark County's comments and concerns. The Board
is also requesting that DOE provide a response to the public's comments prior to the release of the Final
Yucca Mountain EIS. If you have further questions on Clark County's comments please contact Dennis
Bechtel or Staff of the Comprehensive Planning, Nuclear Waste Division.

Sincerely,

B L Woodbury

BRUCE L. WOODBURY
Chairman
Clark County Commission

DEIS Attachments

cc: The Honorable Richard Bryan
The Honorable Harry Reid
The Honorable Shelley Berkeley
The Honorable John Ensign
Kenny Guinn, Governor of the State of Nevada
Dale Askew, County Manager
Richard B. Holmes, Assistant County Manager
John Schlegel, Director of Comprehensive Planning
Affected Units of Local Government

Central DEIS comments/DEIS ltr Feb 00

RESOLUTION OF THE CLARK COUNTY, NEVADA BOARD OF COMMISSIONERS REGARDING THE DRAFT DEPARTMENT OF ENERGY ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

WITNESSETH:

WHEREAS, the Department of Energy (DOE) in August 1999 released a Draft Environmental Impact Statement (DEIS) intended to provide information on potential environmental impacts that could result from the proposed action to construct, operate and monitor, and close a geologic repository at Yucca Mountain, Nevada, and

WHEREAS, Clark County is specified in the DEIS as being in the *Region of Influence*, defined as the specific area of study for each of the resource areas that DOE assessed for the EIS analyses, and

WHEREAS, DOE in 1988 designated Clark County as an "affected unit of local government," under provisions of the Nuclear Waste Policy Act, as amended, in further recognition of the potential impacts to Clark County, its citizens and economy, and

6 **WHEREAS**, Clark County, which includes the incorporated cities of Las Vegas, Boulder City, Henderson, North Las Vegas and Mesquite, is one of the fastest growing counties in the nation with 1.3 million residents, and 32 million visitors, is experiencing severe traffic congestion, and extensive construction activities, and

WHEREAS, the DEIS lists potential options in Clark County for the transportation of commercial spent nuclear fuel and high-level radioactive waste including Interstate 15, the Las Vegas Valley Beltway transportation alignment, currently under construction, rail lines connecting to the Union Pacific Railroad at Valley modified and Jean, and sidings at Apex/Dry Lake and Sloan/Jean, and

WHEREAS, the DEIS fails to consider potential public health and safety effects from the transportation of nuclear waste through Clark County, in particular the Las Vegas Valley, and

7 **WHEREAS**, despite the dependence of Clark County on the volatile economic sector of tourism, the DEIS fails to evaluate impacts to Clark County's economy due to repository operation and transportation, and

WHEREAS, notwithstanding the potential impacts that could occur from the transportation of the nuclear waste, other socioeconomic issues such as impact on quality of life and stigma affects are also not evaluated in the DEIS, and

8 **WHEREAS**, DOE failed to interact appropriately with Clark County government to receive accurate and complete local information during the preparation of the DEIS, and

9 **WHEREAS**, DOE effectively excluded members of minority and low-income groups from the public information process, and

10 **WHEREAS**, The failure of the DEIS to adequately consider the potential impacts to Clark County's economy, public health and safety and quality of life to its citizens is not in the spirit and intent of national environmental policy and requirements.

NOW, THEREFORE, BE IT RESOLVED THAT

11 1. Since Clark County and other issues, appropriately required by the National Environmental Policy Act, are not adequately addressed in the DEIS, a new DEIS or a supplemental EIS for Yucca Mountain must be prepared by DOE to address failures in the current draft DEIS.

2. Clark County's written comments and concerns regarding the DEIS shall be transmitted to the President, Nevada's Congressional delegation, the Council on Environmental Quality, and the leadership of the Senate and House of Representatives.

PASSED, ADOPTED AND APPROVED this 15TH Day of FEBRUARY 2000

CLARK COUNTY BOARD OF COMMISSIONERS

By: ______________________
BRUCE L. WOODBURY
Chairman

ATTEST:

SHIRLEY B. PARRAGUIRRE, County Clerk

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Comments by Clark County, Nevada

U.S. Department of Energy's Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada

Prepared by
Clark County Department of Comprehensive Planning
Nuclear Waste Division
25 February 2000

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Clark County, Nevada Comments, 25 February 2000, DEIS for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada

EXECUTIVE SUMMARY

Introduction

In its capacity as an affected unit of local government under the Nuclear Waste Policy Act, As Amended, Clark County, Nevada, has completed an extensive review of the *Draft EIS*. This document was published in August 1999 and is available for public comment until February 28, 2000. After all comments are reviewed, DOE staff will prepare a final EIS that should reflect consideration of all relevant issues.

The Final EIS will be a key document in the federal approval and licensing process for the proposed repository at Yucca Mountain. Therefore it is of utmost importance that *all* potential impacts of the repository on Clark County are identified and analyzed in the EIS since it will be used by DOE, Congress, DOE and other federal entities to recommend, plan and implement mitigation strategies and programs.

12 As a result of this review and other interactions with the U.S. Department of Energy [the "DOE"], the Clark County Board of County Commissioners recently passed a resolution requesting that the DOE prepare a new *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada [the Draft EIS]*. This action was taken because of a number of major insufficiencies that were identified during the county's review of the Draft EIS.

13 In preparing the Draft EIS, DOE has virtually ignored the standing of Clark County and other affected units of local
government. Not only did they fail to acknowledge the comments provided by Clark County, the State of Nevada
14 and other AULGs in 1995 during the scoping phase of DEIS development, they have also disregarded more accurate
local information (e.g., demographics, development and strategic plans, transportation system) that was readily
available for use in the DEIS.

15 In addition, DOE did not make a diligent effort to involve the public and implement NEPA procedures. In particular, no substantial effort was made by DOE to involve groups that would be affected by the Yucca Mountain Program, especially low-income and minority populations. DOE failed to comply with Executive Order 12898 that directs the agency to consult with states, Native American tribes and local governments to assist in identifying minority and low-income groups so that they may have significant input.

16 Because of the lack of compliance with NEPA requirements, consideration of important individual and cumulative impacts, and inclusion of affected groups in the process, the DEIS is inadequate and incomplete. Therefore, the DEIS does not provide enough scope and detail to allow for meaningful mitigation planning.

The rationale for this statement takes into account the following points. The Draft EIS:

- does not comply with the letter and intent of NEPA since it did not provide a realistic alternative that allows for consideration of a No Action Alternative,
- provided insufficient scope and detail to allow for impact determination that could result in the planning and implementation of mitigation and management plans,
- narrowly defined the scope and nature of impacts, thus assuring that few impacts of significance would be identified. For example, the DEIS ignored potential impact categories important to Clark County's economy and (e.g., stigma effects on tourism, land use conflicts, property diminution and unfunded mandates on local government) although there is credible evidence that shows that these may occur, and,
- failed to include minorities and low-income groups in the scoping, interactive and hearing processes related to the EIS.

Insufficiency and Incompleteness of the Draft EIS

There are a number of reasons why Clark County considers the Draft EIS insufficient or incomplete. For purposes of brevity, we have categorized them into general and specific areas. Within the specific areas, we have identified major impacts not considered in the Draft EIS. In the body of the comments, we have cited NEPA regulations, DOE guidelines, Executive Orders to support our comments.

General Issues

17 - The DEIS does not comply with the letter and intent of NEPA since the DEIS did not provide a realistic alternative that allows for consideration of a No Action Alternative.

18 - DOE did not make a diligent effort to involve the public and implement NEPA procedures. In particular, no substantial effort was made by DOE to involve groups that would be affected by the Yucca Mountain Program, especially low-income and minority populations. DOE failed to comply with Executive Order 12898 that directs the agency to consult with states, Native American tribes and local governments to assist in identifying minority and low-income groups.

19 - DOE did not address rapid and significant changes in population and demography within Clark County, the fastest growing County in the nation. DOE did not consider future growth patterns and attributes of the Clark County population during the project life.

20 - The discussion of cumulative impacts, particularly regarding transportation through Clark County, is inadequate since there is no recognition of upcoming projects at the Nevada Test Site or other activities that would occur at or near the Yucca Mountain site.

Specific Issues

- ***Impacts Related the Yucca Mountain Site***

21 - The disposal canister design evaluated in the DEIS is no longer being considered for license application. It is Clark County's contention that the difference in design is significant enough to invalidate the long-term (10,000 year) performance assessment given in the DEIS. The final EIS should be based on a design that is the same as the one DOE plans to use for license application.

22 - The spent fuel inventory and characteristics given in the DEIS do not accurately represent the spent fuel that the DOE will receive. The final EIS should include an up to date inventory and analysis of the spent fuel that is generated, with due consideration being given to the effect of higher burnup ratios.

23 - In view of the disposal of chemically toxic materials considered for the repository, RCRA regulations should apply.

24 - Saturated Zone data, away from the immediate vicinity of Yucca Mountain, is inadequate. Expert elicitation is not a substitute for data collection. The final EIS should include adequate data for the Saturated Zone, not only in the vicinity of Yucca Mountain, but out to the compliance boundary being considered by the EPA. If this boundary is not fixed by the time the final EIS is issued then the DOE should, as a minimum, have adequate saturated zone data to defend any assumptions that are made regarding the saturated zone.

- ***Impacts Related to Transportation***

25 - Assumptions and methodologies are inadequate or inappropriate for identification and analyses of impacts on the transportation system of Clark County.

26 - The DEIS did not establish a basis for mitigation negotiations since it did not assign specific roles and responsibilities for actions that cause impacts or ameliorate impacts.

27 - There were no estimates of the costs necessary to mitigate the impacts of emergency planning, response, evacuation and cleanup. This approach does not conform to best practice in the field of impact assessment.

28 - The DEIS used outdated databases, geographic data files, and inaccurate or misleading maps to support the conclusions of the transportation, health effects and public safety analyses.

- ***Impacts of Importance to Clark County Not Considered in the DEIS***

29 This section addresses a number of impact areas of importance to Clark County not considered by DOE. If these areas are not addressed in sufficient detail and scope, a meaningful understanding of potential impacts may not take place, and effective mitigation planning and negotiation strategies could not occur. A number of examples are provided to illustrate potential impacts from Yucca Mountain activities.

- There are a number of potential impacts that could be adverse to Clark County residents, visitors, and businesses, harm the quality of life of residents and adversely affect the economic well-being of the County and State.
- In view of Clark County government's objective to sustain the vibrancy of our area, we must take steps to maintain the economic base for its residents, managing its rapid growth, assuring healthy communities and opportunities for its residents, and preserving the natural environment.
- The DEIS does not consider "stigma induced" impacts. As an example, there exists substantial evidence that demonstrates the real potential for serious property value declines and disinvestment from similar programs. Data indicate that stigma induced changes can occur even under incident-free transportation conditions. At a minimum, stigma-induced impacts if present can result in diminution of property values and business performance, development and investment along routes, and decreases in tourism. The importance of this is underscored by the fact that a number of organizations whose constituencies may be adversely affected have expressed their deep concerns. These organizations include the Southern Nevada Home Builders Association, the Greater Las Vegas Association of Realtors®, the Howard Hughes Corporation, and others.

Public Participation in the Draft EIS Review Process

30 Clark County staff met with 19 Town Advisory Boards / Citizens' Advisory Councils, representatives from local jurisdictions and other groups to exchange information and receive comments on the Draft EIS. It is clear from the comments recorded that not only county officials, but also citizens, are very concerned about the negative impacts that the Yucca Mountain Program may have on Southern Nevada.

- Specific issues raised in the comments include the need to acknowledge and assess the impacts on Native Americans, and more fully consider public safety, environmental impacts, environmental justice, funding to local governments, effects on land use, perception-based impacts of DOE activities, performance assessment, interaction of the repository program of local and regional plans, public participation, regulatory standards, schedule & licensing, socio-economic impacts, storage, and transportation issues.

1.0 INTRODUCTION

Primary Reference: DEIS Chapters 1, 11

Major Points of This Chapter:

- The EIS is a key document in the federal approval and licensing process for the proposed repository at Yucca Mountain. It is, therefore, of utmost importance that *all* potential impacts of the repository on Clark County are identified and analyzed in the EIS since it will be used by DOE, Congress, DOE and other federal entities to recommend, plan and implement mitigation strategies and programs.

31 *In preparing the DEIS, DOE has:*

- Virtually ignored the standing of Clark County and other affected units of local government (AULG), as specified in the Nuclear Waste Policy Act (NWPA), as amended
- Ignored the comments provided by Clark County, the State of Nevada and other AULG in 1995 during the scoping phase of DEIS development.
- Disregarded more accurate local information (e.g., demographics, development and strategic plans, transportation system, etc.) available for use in the DEIS
- Refused to acknowledge information and reference documents provided by Clark County and other AULGs that documented key impact areas of importance and concern to affected communities.

32 *The DEIS is insufficient and incomplete with regard to National Environmental Policy Act requirements, Executive Order 12898, and professional practice because the DEIS:*

- Provided insufficient scope and detail to allow for impact determination that could result in the planning and implementation of mitigation and management plans,
- Narrowly defined the scope and nature of impacts, thus assuring that few impacts of significance would be identified. For example, the DEIS ignored potential impact categories important to Clark County's economy and (e.g., stigma effects on tourism, land use conflicts, property diminution and unfunded mandates on local government) although there is credible evidence that shows that these may occur.
- Failed to include minorities and low-income groups in the scoping, interactive and hearing processes related to the EIS.

1.1 Rationale and Importance of Clark County Comments

The information available and evaluated in the EIS are important in assessing whether Yucca Mountain is suitable as a permanent repository for spent commercial nuclear fuel and high-level radioactive waste. Should the Secretary of Energy recommend that the President approve Yucca Mountain as suitable for the development of a repository, the Final EIS (FEIS) will be submitted with the *Site Recommendation Considerations Report*. The FEIS will also accompany an application to the Nuclear Regulatory Commission (NRC) for their analysis regarding whether Yucca Mountain can be licensed as a nuclear waste repository.

33... Congress, the NRC and others will also employ the DEIS as a major source of information on potential program impacts. Therefore, it is important to Clark County, other affected units of government (AULG), and the State of Nevada that the DEIS adheres to NEPA guidelines and accurately and completely describes potential impacts to our communities from Yucca Mountain Program activities.

To the extent that local impacts are not addressed or inadequately addressed in the DEIS, the chances increase that Congress may not consider, or even be aware of, potentially substantive impacts to AULG. Clark County is concerned that impacts not noted in a document required by the NWPA could result in the disallowance of

33 cont. mitigation requests even when supported by other documentation. This is a major factor requiring Clark County, Nevada, to strongly object to the DEIS in its present form. To meet the demands of the National Environmental Policy Act (NEPA) the DEIS must characterize and describe potential Yucca Mountain program-related impacts that may affect our communities. To this DOE has failed in this document.

34 In preparing the DEIS, DOE has ignored community issues that should have been appropriately addressed under NEPA. These will be discussed in greater detail later in the review. DOE has also ignored the reason why it is important for a community to have these issues considered. The mandated role of local government is to protect the general welfare of its residents, and in the case of Clark County, the millions of tourists that visit Las Vegas and Clark County annually. DOE managers, scientists and technicians have prepared the DEIS according to the rules of applied science and levels of probability. However, DOE has failed to take into account that potential impacts that communities have to consider are often defined by courts and the public's view of the potential risk involved.

Clark County recognizes that legitimate debate can take place about the relevance or the extent of a particular impact. It is our contention, however, that any potential impact of importance to affected parties must at least be acknowledged in the DEIS. For example, impacts on tourism in Clark County should be considered in the DEIS since this is an issue that affects strategic plans and day-to-day activities of local governmental officials and members of the public.

Tourism and gaming are Clark County's, and the State of Nevada's major economic drivers. Almost half the State of Nevada's revenue is generated by gaming, and fully 70% of that gaming revenue is generated in Clark County. The convention industry, a major subset of tourism, attracts enough groups and individuals to the area to make Clark County the largest convention destination in the U.S. Despite their importance to Clark County, potential impacts to this key economic sector was not even considered in the DEIS.

35 Impacts to Las Vegas are in great part the result of DEIS consideration of many potential alternate truck or rail transportation routes in Clark County, a majority traversing the Las Vegas Valley. The highway and rail routes noted in the DEIS would result in shipments of nuclear waste being transported on Interstate 15, adjacent to the "Strip," the location of most of Clark County's major casinos, and U.S. 95, where an increasing number of hotels and casinos are being constructed.

The transport of nuclear waste through Las Vegas, particularly with our substantial growth and traffic congestion, offers a greater potential for accidents. The implications to a tourist-based economy are many. Whether or not an accident results in the release of radioactivity, it is certain that it would lead to widespread media coverage. Such publicity could result in decisions by potential visitors to avoid Las Vegas. Convention planners, who have to consider liability and responsibility to their clients, could also advise their customers to consider other destinations. Conceivably, an accident could negatively affect Clark County's economy. However, DOE dismisses "*risk perception and stigmatization*" as "*not related to the proposed action,*" even though in this case economic impacts may result from public perception of the risk involved. (See Page S-9 of the Summary document). An examination of the implications of routing selection in the DEIS would have lead to a consideration of the potential impacts that could occur. Other examples will be cited later in our review.

36... To understand concerns such as these, DOE needs to reflect on how local elected officials consider a major federal project such as the one being proposed in the DEIS. In making decisions, local officials must use any information, no matter how uncertain or well defined, to consider the implications to their constituents. This basic criterion may be stated as follows, "*Is an event or impact from that event more likely than not to happen and, if so, what must we do to mitigate any harmful effects?*"

In other words, the standard of proof for technical or statistical decision-making may have the appearance of being more stringent but it is generally much less related to the real world than that which needs to be

36 cont. considered by local elected officials and the public when evaluating the effects of major projects. It should also be noted that technical or statistical data, even when applied with accepted "industry" standards, often provide an artificial appearance of reality. Often there isn't sufficient experience, information or data to substantiate the numbers.

It is this need on the part of local governments that must be met in order for an environmental impact statement to reflect reality. Thus, DOE does a great disservice to local communities when the DEIS is not written to take into account the potential effects of the Yucca Mountain Program on the economy of Clark County and in other potential impact areas. For example, effects on program costs and the liability of local governments, on the necessity for transportation infrastructure improvements, on the potential loss of value of property, and the potential stigmatization of local area services and products have all been documented as impacts elsewhere. But, they have not been addressed in the Yucca Mountain DEIS. To reiterate, while there may be questions regarding the present or future occurrence of such impacts and their potential magnitude, it is important that there at least be acknowledgement of the issues in the DEIS.

If these impacts of greatest concern to the residents and elected officials of Clark County are not addressed, there can be no reasonable expectation that meaningful mitigation planning can take place. Since a major goal of an EIS is to provide a broad enough scope and enough detail to allow for such action, this DEIS must be considered incomplete and insufficient.

1.2 Role of Clark County in the Yucca Mountain Program

Since 1983 Clark County has fulfilled its responsibilities under the Nuclear Waste Policy Act of 1982, and its subsequent amendments in 1987 and 1992 (NWPA). In April 1988, acknowledging potential impacts to our community from the Yucca Mountain Program, Clark County was designated by DOE as an affected unit of local government (AULG) under provisions of the NWPA[1]. The stipulated roles and responsibilities of Clark County under the NWPA are consistent with its mandate as a subdivision of the State of Nevada and its responsibilities to protect the health, safety and welfare of its residents.

The County's concerns about potential impacts from the repository project were first stated immediately after passage of the NWPA in a 1983 issue paper and memorandum[2] to the Clark County Manager written by the then director of the Department of Comprehensive Planning. This memorandum not only reflects the County's responsibility as an AULG under the NWPA, but also its governmental mission as seen in the lengthy history of actions by the County Commissioners and agencies aimed at overseeing the Yucca Mountain program.

A portion of the 1983 memo noted:

> *"It is important that issues pertinent to Clark County and local entities are considered at the earliest date. In addition to ensuring that impacts are minimized, it is also important to make the federal government aware of the degree of local concern about: a) the project, and b) the fact that Clark County and its citizens would be the best judge on determining what local impacts would result.*" (Donald Shalmy memorandum to County Manager Spaulding, December 1983).

The 1983 briefing report was a response to a request for information from a county commissioner and raised five issues that Clark County and local entities needed to carefully consider to ensure that impacts would be minimized. These issues were stated as:

- emergency response;
- transportation routes and modes;
- socioeconomic considerations, including employment and impacts from construction;
- perceptual issues and their influence, for example, on tourism, and quality of life; and,
- funding to mitigate and minimize impacts and for the analysis of potential impacts from the project.[2]

Although additional important matters such as environmental justice, fiscal impacts on government, and greater public involvement have been added, these five issues have remained part of the core County concerns, as reflected in this response to the DEIS and a host of other county formal communications with the DOE. The following sections will provide background on the County's efforts to investigate these issues within its governmental and AULG mandates. The ongoing interactions between the County and the DOE and their effects on the county program will also be discussed.

1.3 Interagency/Intergovernmental Interactions, NEPA Requirements and the Nuclear Waste Policy Act

1.3.1 Interaction with Clark County and other Affected Units of Local Government

37... In the DEIS, Appendix C, DOE listed and described interactions that it has had with federal, Native American, State of Nevada, AULG and other agencies. In most cases, DOE provided brief descriptions of the authority or interest that each organization holds and the nature of the interactions. With this emphasis on brevity, the Appendix provides little substantive information that may be used to identify the concerns of each entity and possible analysis of these issues in the DEIS.

Section 116[c](1)(B) of NWPA formally recognizes affected units of local government in the Yucca Mountain Program. In 1985, the Clark County Board of County Commissioners adopted a resolution opposing the selection of the Yucca Mountain site, and in early 1988 a resolution declared the county an AULG. Hence, the County Commissioners' actions were in full compliance with the NWPA, and they agreed that as an AULG, the County would assume the following roles and responsibilities:

- Determine any potential economic, social, public health and safety, and environmental impacts of the repository on the state, affected unit of local government and its residents;
- Develop a request for impact assistance (if appropriate);
- Engage in monitoring, testing or evaluation activities with respect to site characterization activities;
- Provide information to state (county) residents regarding any activities of the State, County, the Secretary of Energy, or the Nuclear Regulatory Commission with respect to the site; and,
- Request information from, and *make comments and recommendations to the DOE on actions they have taken* (Section 116 [c](1)(B), emphasis added).

This response to the DEIS clearly falls under this last bulleted mandate and the NEPA (discussed below). In addition, the County has responsibility to protect the health, safety, and welfare of its residents under the General Welfare Clause. Should the repository siting, operation, or transportation of waste have negative impacts, the County is required to provide protection to its residents. To fulfill this responsibility, the County has made and will continue to make extensive efforts to communicate its concerns about potentially negative impacts to the DOE.

Prior to the EIS Scoping Meetings in 1995, all ten of the AULG met with then Secretary of Energy O'Leary, and the Under Secretary of DOE to describe our role in the NWPA and amendments, and to discuss issues of importance. Clark County noted that one of the key factors, still missing from the program, was that the AULG's effective involvement in any program was contingent on DOE's acknowledgement of the role of local governments as pre-decisional participants in all phases of the siting process.[3,4] In this and other meetings, Clark County clearly indicated the importance that it attached to the full implementation of NEPA provisions.

Clark County further attempted to demonstrate to DOE the importance attached by its decision-makers to potential negative impacts and the importance of the EIS process. We commented on DOE's Notice of Intent with a document entitled, "A Review of Impact Assessment Concerns."[5] This document was transmitted to DOE in compliance with the DOE EIS Scoping requirements, and contained an examination of the major concerns and issues that Clark County believed needed to be addressed in the impact assessment effort. The

37 cont. issues raised in the document were the result of years of studies by Clark County, the State of Nevada, and other local governments, and years of meetings in which these and other issues were discussed.

In brief, these issues included the following:

- Property value diminution;
- Regional traffic disruptions;
- Inequitable distribution of risk—environmental justice;
- Project-related business and population impacts;
- Negative impacts on the visitor economy;
- Local government finance imbalance resulting from project related costs; and,
- Political and institutional conflict resulting from the program causing local political instability.

These concerns are further considered in later sections of the review. It is important to note that the County also communicated to DOE that the concerns of the public and elected officials that these were important stakeholder issues that should have been addressed completely and adequately in the EIS.

A 1998 meeting between the AULGs and DOE led to an agreement that any of the counties may provide reference material to DOE for use in the DEIS and EIS process. In response to this, Clark County submitted a reference document entitled, "*Comments, Findings and References Regarding The Draft Yucca Mountain Environmental Impact Statement.*" This submittal was designed to [1] highlight significant issues that Clark County believes the DOE must address in meeting its responsibilities under NEPA, [2] present findings and contextual information regarding the comments listed, and, [3] provide references to substantiate the comments and findings discussed. The reference document described the County's concerns in eight areas, including:

- Public and institutional processes
- Scope and policy
- Cumulative impacts and integration with other EISs
- Methodology
- Public health and safety
- Transportation
- Environmental justice
- Fiscal and economic effects.

The accompanying letter stated that, *"The EIS is for Clark County and the other AULGs the most important document produced in this program"*[6] The letter also stated that a major strength that Clark County brings to the EIS process is that it has a comprehensive knowledge of its geographical area of responsibility. This submittal was an attempt by the County to aid in producing a better EIS by offering its cooperation and expertise, and by requesting that Clark County and the other AULGs be brought into the process prior to the completion of the DEIS. The letter went on to request that these materials, *"be cited in the EIS by the DOE where appropriate, placed in public reading rooms along with other EIS materials, furnished directly upon request to interested persons, and otherwise made accessible through electronic and/or hard copy means."*[7]

Under NEPA provisions, the DOE was required to make all reference materials available to the public and others for at least the full public comment period. Despite DOE assurances, these actions were not taken and the reference documents provided by Clark County and several other AULGs were not cited in the DEIS nor were they included as an appendix. In fact, the DEIS made the erroneous statement that only Nye county submitted such comments.

This decision by DOE not to include Clark County and other AULG documents was a violation of an agreement between two governmental entities both possessing legal standing under the NWPA.

37 cont. DOE had repeatedly assured the county that these issues and concerns would be addressed in the DEIS. However, there is little in the document that shows that DOE took these comments seriously. Despite the fact that the County comments drew heavily on the *Environmental Assessment Checklist* developed by the DOE Office of NEPA Oversight, many of its comments were not addressed. Consequently, critical issues to Clark County are either not addressed, poorly addressed, or not realistically addressed in the DEIS.

38 Such inaction by DOE during the scoping and DEIS process may be a violation of NWPA Section 117, that states that if Nevada [and AULGs] or a tribe makes a written request for information, the Secretary of Energy has 30 days to answer. If not answered, the request would go to the President. If s/he does not reply in writing within 30 days, the process of site characterization must be suspended until a written answer is provided. This provision has not been implemented nor has it been followed by the Department of Energy.

REFERENCES

[1] Nuclear Waste Policy Act of 1982, As Amended (Public Law 97-425; 96 Stat. 2201S), as amended by P.L. 100-203 (1987) and P.L. 102-486 (The Energy Policy Act of 1992); generally classified to 42 U.S.C. 10101 and following.

[2] Shalmy, D., Memorandum to Bruce Spaulding, County Manager, December 21, 1983

[3] Affected Units of Local Government, (January 13, 1995). Meeting with the Secretary and Under Secretary U.S. Department of Energy.

[4] Overview of the Clark County, Nevada Nuclear Waste Repository Program. (November 6, 1991). "Yucca Mountain and Governmental Trust Issues: The Perspective from Clark County. Presented before the Secretary of Energy Advisory Board Task Force on Civilian Radioactive Waste Management.

[5] Clark County Department of Comprehensive Planning, Nuclear Waste Division, "DOE's High-Level Nuclear Waste Program: A Review of Impact Assessment Concerns." Clark County Department of Comprehensive Planning, Nuclear Waste Division, December 1995.

[6] Letter to W. Dixon, OCRWM, DOE North Las Vegas Office, from D. Bechtel, Nuclear Waste Division, Clark County Department of Comprehensive Planning. December 7, 1998.

2.0 GENERAL ISSUES REGARDING THE DRAFT EIS

Major Points of This Chapter:

39 ▪ The DEIS does not comply with the letter and intent of NEPA since the DEIS did not provide a realistic alternative that allows for consideration of a No Action Alternative.

40 ▪ DOE did not make a diligent effort to involve the public and implement NEPA procedures. In particular, no substantial effort was made by DOE to involve groups that would be affected by the Yucca Mountain Program, especially low-income and minority populations. DOE failed to comply with Executive Order 12898 that directs the agency to consult with states, Native American tribes and local governments to assist in identifying minority and low-income groups.

41 ▪ DOE did not address rapid and significant changes in population and demography within Clark County, the fastest growing County in the nation and in Las Vegas, the fastest growing city in the nation. DOE did not consider future growth patterns and attributes of the Clark County population during the project life..

42 ▪ The discussion of cumulative impacts, particularly regarding transportation through Clark County, is inadequate since there is no recognition of upcoming projects at the Nevada Test Site or other activities that would occur at or near the Yucca Mountain site.

43 ▪ Because of the lack of compliance with NEPA requirements, consideration of important individual and cumulative impacts, and inclusion of affected groups in the process, the DEIS is inadequate and incomplete. Therefore, the DEIS does not provide enough scope and detail to allow for meaningful mitigation planning.

2.1 Introduction

In this section, Clark County will provide comments on general, or crosscutting issues, regarding the Yucca Mountain EIS. First, the four parts of this section include general discussions about DOE's compliance with the letter and intent of NEPA, public involvement processes during scoping and the DEIS comment period, and the DEIS consideration of environmental justice and cumulative impacts. Then, in each part, comments and NEPA references are provided regarding specific DEIS treatment of these issues.

This approach will be repeated, as appropriate, in our comments regarding issues related to the site, transportation and other impact areas.

2.2 Review of DOE Compliance with NEPA Letter and Intent

Primary Reference: DEIS Ch. 1, 11, App. B]

44 The DEIS falls short of NEPA requirements in a number of areas. First, the alternatives identified to the Proposed Action are unreasonable and incomplete. While NEPA does not require every possible alternative to be considered, it does require that all "reasonable" alternatives to the proposal be considered. Further, NEPA also requires that the alternatives be considered that are beyond what the applicant "likes or is itself capable of carrying out" (46 Fed. Reg. 180266). As currently drafted, the alternatives outlined in the DEIS do not meet these requirements.

45... The DEIS also does not contain sufficient detail in order to evaluate mitigation needs. While this may be addressed in future documents, the current DEIS language provides no guarantees. Thus, a whole range of issues and responsibilities are left ambiguous. This could result in a significant harm to the residents of Clark

45 cont. County. There are also methodological and data problems within the DEIS, especially, as they relate to population health risks, uncertainties in site characterization models, and the analysis of environmental justice
597 impacts.

46 Clark County provides a detailed commentary to the DOE regarding the DEIS. We recommend that DOE begin a second phase analysis of key NEPA issues identified within this review, especially with regard to case law that specifically supports the Clark County's position that certain types of impacts be investigated.

For example, an initial examination of the case law that is purported to support the DOE's contention that stigma need not be addressed within the DEIS, *Metropolitan Edison Company v. People Against Nuclear Energy* (460 US 766, 103 S.Ct. 1556, 75 L/Ed. 534 (1983)), indicates that the scope of impact assessment may actually be much narrower than DOE's.

47 Finally, the DEIS violates the spirit of NEPA by not revealing the transportation routes that were analyzed for shipment of the SNF and HLW. The lack of information in the DEIS runs contrary to previous DOE practices that considered the Waste Isolation Pilot Project (WIPP) EIS and Supplemental EIS.

48 The current DEIS falls far short of what is needed for such a major federal project as the Yucca Mountain Program. Clark County recommends that DOE withdraw the current DEIS and undertake the investigations necessary to produce an EIS that fully describes the impacts and appropriate mitigation alternatives in order for the President to make an informed decision on the suitability of the repository.

2.2.1 DEIS Assumptions, Scope and Policy; Relationship to NEPA and Other Federal Requirements

The specific comment groups hereafter are organized in the following manner. A selection from the DEIS is followed by a Clark County comment regarding its adequacy or potential impact on Clark County. This is then referenced to an appropriate section(s) of NEPA, the Nuclear Waste Policy Act and/or other federal directives.

For the reader's convenience, we have included the text of any cited NEPA regulations prior to the comments. We have also included selected text from an EPA publication, "Forty Most Asked Questions Concerning CEQ's NEPA Regulations" and Presidential Executive Order 12898.

NEPA Regulation: *Sec. 1502.1 Purpose. It shall provide full and fair discussion of significant environmental impacts and shall inform decision-makers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment.*

NEPA Regulation: *Sec. 1502.2 Implementation. To achieve the purposes set forth in Sec. 1502.1 agencies shall prepare environmental impact statements in the following manner: (e) The range of alternatives discussed in environmental impact statements shall encompass those to be considered by the ultimate agency decision-maker.*

NEPA Regulation: *Sec. 1502.14. Alternatives including the proposed action. Based on the information and analysis presented in the sections on the Affected Environment (Sec. 1502.15) and the Environmental Consequences (Sec. 1502.16), an EIS should present the environmental impacts of the proposal and the alternatives in comparative form, thus sharply defining the issues and providing a clear basis for choice among options by the decision-maker and the public. In this section agencies shall:*

(a) Rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated.
(b) Devote substantial treatment to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits.
(c) Include reasonable alternatives not within the jurisdiction of the lead agency.
(d) Include the alternative of no action.

(e) Identify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative in the final statement unless another law prohibits the expression of such a preference.
(f) Include appropriate mitigation measures not already included in the proposed action or alternatives.

NEPA Regulation: *Sec. 1502.16 Environmental consequences. This section forms the scientific and analytic basis for the comparisons under Sec. 1502.14. It shall consolidate the discussions of those elements required by sections 102(2)(C)(i), (ii), (iv), and (v) of NEPA which are within the scope of the statement and as much of section 102(2)(C)(iii) as is necessary to support the comparisons. The discussion will include the environmental impacts of the alternatives including the proposed action, any adverse environmental effects which cannot be avoided should the proposal be implemented, the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and any irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented. This section should not duplicate discussions in Sec. 1502.14.*

NEPA Regulation: *Sec. 1502.22 Incomplete or Unavailable Information. When an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an environmental impact statement and there is incomplete or unavailable information, the agency shall always make clear that such information is lacking.*

(a) If the incomplete information relevant to reasonably foreseeable significant adverse impacts is essential to a reasoned choice among alternatives and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the environmental impact statement.

Forty Most Asked Questions Concerning CEQ's NEPA Regulations.

19a. Mitigation Measures. What is the scope of mitigation measures that must be discussed?

The mitigation measures discussed in an EIS must cover the range of impacts of the proposal. The measures must include such things as design alternatives that would decrease pollution emissions, construction impacts, esthetic intrusion, as well as relocation assistance, possible land use controls that could be enacted, and other possible efforts. Mitigation measures must be considered even for impacts that by themselves would not be considered "significant." Once the proposal itself is considered as a whole to have significant effects, all of its specific effects on the environment (whether or not "significant") must be considered, and mitigation measures must be developed where it is feasible to do so. Sections 1502.14(f), 1502.16(h), 1508.14.

19b. How should an EIS treat the subject of available mitigation measures that are (1) outside the jurisdiction of the lead or cooperating agencies, or (2) unlikely to be adopted or enforced by the responsible agency?

All relevant, reasonable mitigation measures that could improve the project are to be identified, even if they are outside the jurisdiction of the lead agency or the cooperating agencies, and thus would not be committed as part of the Records of Decision of these agencies. Sections 1502.16(h), 1505.2(c). This will serve to [46 FR 18032] alert agencies or officials who can implement these extra measures, and will encourage them to do so. Because the EIS is the most comprehensive environmental document, it is an ideal vehicle in which to lay out not only the full range of environmental impacts but also the full spectrum of appropriate mitigation.

However, to ensure that environmental effects of a proposed action are fairly assessed, the probability of the mitigation measures being implemented must also be discussed. Thus, the EIS and the Record of Decision should indicate the likelihood that such measures will be adopted or enforced by the responsible agencies. Sections 1502.16(h), 1505.2. If there is a history of non-enforcement or opposition to such measures, the EIS and Record of Decision should acknowledge such opposition or non-enforcement. If the necessary mitigation measures will not be ready for a long period of time, this fact, of course, should also be recognized.

Executive Order 12898. *Agencies should consider the composition of the affected area, to determine whether minority populations, low-income populations, or Indian tribes are present in the area affected by the proposed action, and if so whether there may be disproportionately high and adverse human health or environmental effects on minority populations, low-income populations, or Indian tribes.*

Agencies should consider relevant public health data and industry data concerning the potential for multiple or cumulative exposure to human health or environmental hazards in the affected population and historical patterns of exposure to environmental hazards, to the extent such information is reasonably available. For example, data may suggest there are disproportionately high and adverse human health or environmental effects on a minority population, low-income population, or Indian tribe from the agency action. Agencies should consider these multiple, or cumulative effects, even if certain effects are not within the control or subject to the discretion of the agency proposing the action.

Agencies should recognize the interrelated cultural, social, occupational, historical, or economic factors that may amplify the natural and physical environmental effects of the proposed agency action. These factors should include the physical sensitivity of the community or population to particular impacts; the effect of any disruption on the community structure associated with the proposed action; and the nature and degree of impact on the physical and social structure of the community.

2.2.2 Clark County Comments and NEPA Citations Regarding Specific DEIS Statements: DEIS Scope, Alternatives, Scenarios, Costs, Mitigation

49 **DEIS Statement (pg. 1-23)** - Many other public scoping comments presented views and concerns not related to the scope or content of the Proposed Action. Examples of such comments include lack of public confidence in the Yucca Mountain program, inequities and political aspects of the siting process by which Yucca Mountain was selected for further study by Congress, risk perception and stigmatization, legal issues involving Native American land claims and treaty rights, and unrelated DOE activities. DOE considered and recorded these concerns in the comment summary document on the scoping process (DOE 1997a, all), but has not included analyses of these issues in the EIS.

Clark County Comment - DOE has taken certain impacts of concern to Clark County and characterized them as "not related to the scope of the Proposed Action." While these may not be of concern to DOE, they form important bases for decision-making among county elected officials, community leaders, business personnel and individuals. These include concerns about the impacts of tourists' and visitors' perceptions of risk and potential consequences of these perceptions, predictions about the effects on commerce by business personnel, and concerns about health, welfare and economic well-being of county residents. Investigations of these matters and others, including stigma to area products and services, and the equity of risks to various populations have been requested by the State of Nevada, Clark County, other AULGs and a number of individuals. *NEPA Regulation: Sec. 1502.14 Alternatives including the proposed action.*

50 **DEIS Statement (pg. 2-1)** - DOE does not intend to represent the No-Action Alternative as a viable long-term solution but rather to use it as a baseline against which the Proposed Action can be evaluated.

Clark County Comment - Under the requirements of NEPA, DOE should have a realistic alternative that allows for the consideration of No-Action. DOE's No-Action Scenario 1 is not realistic in that it provides for institutional controls for 10,000 years if spent nuclear fuel (SNF) and high level radioactive waste (HLW) remains stored at nuclear power plants. At the other extreme, No-Action Scenario 2 drops institutional controls after 100 years. Scenario 1 may not be possible and Scenario 2 would not reflect appropriate and likely governmental actions. *NEPA Regulation: Sec. 1502.14 Alternatives including the proposed action*

51... **EIS Statement (pg. 2-65) 2.2.2.2** - In No-Action Scenario 1, DOE would continue to manage its spent nuclear fuel and high-level radioactive waste in above-or-below-grade dry storage facilities at five sites around the

51 cont. country. Commercial utilities would continue to manage their spent nuclear fuel at 72 sites. The commercial and DOE sites would remain under effective institutional control for at least 10,000 years. DOE based the 10,000-year analysis period on the generally applicable Environmental Protection Agency regulation for the disposal of spent fuel and high-level radioactive waste (40 CFR Part 191), even though the regulation would not apply to disposal at Yucca Mountain.

Clark County Comment - This alternative is not authentic since it posits that institutional controls would remain for 10,000 years at 77 facilities that currently store spent fuel. DOE's alternative for institutional controls should be reasonably comparable. It is not reasonable to compare relaxed standards of the Nuclear Waste Policy Act with a more restricted national standard. Further, under this scenario, storage facilities would be completely replaced every 100 years. This artificially distorts the cost of a "realistic" on site storage for an interim period of 20-50 years while a fair search for an appropriate disposal solution is sought. Further, HLW at DOE facilities throughout the country are the responsibility, in perpetuity, of the DOE. Replacement of buildings at these facilities should not be factored into the costs of the No-Action alternative. The spirit of NEPA requires the formulation of realistic scenarios in order to identify alternatives, impacts and potential mitigation strategies. The DEIS fails to meet the spirit and letter of NEPA in this regard. *NEPA Regulation: Sec. 1502.14 Alternatives including the proposed action; Sec. 1502.16 Environmental consequences.*

52 **DEIS Statement (pg. 2-67) 2.2.2.3** - In No-Action Scenario 2, spent nuclear fuel and high-level radioactive waste would remain in dry storage at commercial and DOE sites and would be under effective institutional control for approximately 100 years (the same as Scenario 1). Beyond that time, the scenario assumes no effective institutional control. Therefore, after about 100 years and up to 10,000 years, the analysis assumed that the spent nuclear fuel and high-level radioactive waste storage facilities at 72 commercial and 5 DOE sites would begin to deteriorate and that the radioactive materials in them could be released into the environment. DOE based the choice of 100 years on a review of generally applicable Environmental Protection Agency regulations for the disposal of spent nuclear fuel and high-level radioactive waste.

Clark County Comment - This alternative is also biased because it assumes that if the Yucca Mountain repository is not approved, there will be no solution for nuclear waste disposal for 10,000 years. Further, it assumes that after 100 years institutional controls will be removed. If no nuclear waste disposal solution is forthcoming after 100 years, it is unlikely that institutional controls will be abandoned. *NEPA Regulation: Sec. 1502.14 Alternatives including the proposed action; Sec. 1502.2 Implementation.*

53 **DEIS Statement (pg. 2-67) 2.2.3** - The estimated cost of both Scenarios 1 and 2 for the first 100 years ranges from $51.5 billion to $56.7 billion, depending on whether the dry storage canisters have to be replaced every 100 years. The estimated cost for the remaining 9,900 years of Scenario 1 ranges from $480 million to $529 million per year. There are no costs for Scenario 2 after the first 100 years because the scenario assumes no effective institutional control.

Clark County Comment - Because of the faulty scenarios put forth in the DEIS, the cost data in section 2.2.3 has no basis. DOE should provide a No Action set of scenarios that at least are protective of the public health and safety. The scenarios should also incorporate both institutional and passive controls at the current storage sites that are comparable to what DOE intends to use at the proposed repository. *NEPA Regulation: Sec. 1502.14 Alternatives including the proposed action; Sec. 1502.16 Environmental consequences.*

54... **DEIS Statement (pg. 2-79), 2.4**

- From 0.04 to 0.4 square kilometer (10 to 100 acres) of land could be contaminated to the extent it would not be usable for long periods near each of the 77 sites for No-Action Scenario 2. There could be accompanying impacts on biological resources, socioeconomic conditions, cultural resources, and aesthetic resources for long periods. Such impacts for the Proposed Action and No-Action Scenario 1 would be very small.

54 cont.

- For No-Action Scenario 2, there could be low levels of contamination in the surface watersheds and high concentrations of contaminants in the groundwater downstream of the 77 sites for long periods. There would be no such impacts for No-Action Scenario 1. For the Proposed Action, there could be low levels of contamination in the groundwater in the Amargosa Desert for a long period.
- Projected radiological impacts to the public for the first 10,000 years for the Proposed Action would be low (0.00055 to 0.00053 latent cancer fatality per year) compared to No-Action Scenario 2 (3,300 latent cancer fatalities).
- Radionuclides would be released for a long period of time under the Proposed Action and peak doses would occur hundreds of thousand years after closure of the repository.
- Projected long-term fatalities associated with No-Action Scenario 1 would be about 1,000, primarily to the workforce at storage sites.
- Risks associated with sabotage and materials diversion in relation to fissionable material stored at the 77 sites would be much greater than they would be if the fissionable material were in a monitored deep geologic repository.

The projected cost associated with No-Action Scenario 1 would be approximately $600 million a year (1998 dollars) for 9,900 years. Projected long-term costs for the Proposed Action would be very low while there would be none for No-Action Scenario 2 due to the lack of institutional control.

Clark County Comment - Since the No-Action scenarios are unreasonable, the forecasted impacts are invalid. *NEPA Regulation: Sec. 1502.16 Environmental consequences; Sec. 1502.22 Incomplete or unavailable information*

55 **DEIS Statement (p. 9-5) 9.2.2.2** – The DEIS asserts that the Yucca Mountain vicinity is isolated from concentrations of human population and human activity and is likely to remain so.

Clark County Comment – This statement is not supportable given the rate of growth in the Amargosa Valley area and the rapidly expanding growth of northern Clark County. Expansion in the Amargosa Valley (and indeed southern Nevada) would most likely be limited by the availability of ground water. Therefore, any reduction in the water available for farming and/or other development is an important impact to that area. Considering the hydrologic basin that receives water from the Yucca Mountain area as "sparsely populated" may be true today, but considering the rapid growth in this area this statement cannot "hold water" for the period of repository construction and operation. *NEPA Regulation: Sec. 1502.16 Environmental consequences.*

2.3 Public Involvement

Primary Reference: DEIS Ch 1

56... Federal code requires that agencies "make diligent efforts to involve the public in preparing and implementing their NEPA procedures" (40 CFR 1506.6(a)). It goes on further to say that they are required "to inform those persons and agencies *who may be interested or affected*" (40 CFR 1506.6(b), [emphasis added]. However, in the DEIS, DOE does not demonstrate how they have made diligent effort to involve those who may be interested or affected.

40 CFR 25.3, *Requirements for RCRA Public Participation*, requires access to the decision-making process by the public. The participation guidelines expect public "access" to the decision-making process, and expect that "dialogue" be created. That is, the agency must assimilate public viewpoints and purposes, and then demonstrate that this assimilation has occurred.

The NWPA states that public participation is "essential to promote public confidence in the safety of [the repository]", so, therefore, "appropriate procedures must be taken to ensure [that the Yucca Mountain Site Characterization Plan and attributes of the site] do not adversely affect public health and safety and the environment for this or future generations."

56 cont. Public participation under Executive Order 12898, and the DOE Environmental Justice Strategy, which are binding upon the preparation of the DEIS, require that six principles must be implemented:

- Agencies should consider the composition of the population in areas affected by actions, whether minority or low-income communities or Indian tribes are present, and whether there may be disproportionately high and adverse effects on them.
- Agencies should consider data regarding potential multiple or cumulative exposures.
- Agencies should recognize that cultural, social, occupational, historical, or economic factors may amplify effects of actions; for example, effects on populations with heightened sensitivities to exposures, or effects on community structure.
- Agencies should develop public participation strategies, and acknowledge and strive to overcome barriers to participation.
- Agencies should assure early and meaningful representation in agency processes of all groups within the affected population.
- Agencies should seek representation from Indian tribes affected by actions.

The Council on Environmental Quality stipulates that these six principles include translation of documents, and the holding of hearings in more than one language if and as needed, and that a Federal agency must ensure that all documents and hearings shall be understandable.[1] What has been done to implement this requirement of environmental justice? There is no Spanish translation of the DEIS available, reports, notifications and newsletters are not published in Spanish even though the DOE is aware that a significant proportion of the residents of Nevada and along potential transportation routes speak and read Spanish as their first language. Likewise, interpreters were not present at DOE hearings.

More deeply, since 'understand' is not confined to 'use my language,' we must ask what efforts DOE has made to translate its thoughts, evidence, plans or proposals into standard English as utilized by the majority, lay population? There has been very little such effort to interpret often complex concepts into standard English.

Although some portions of the DEIS show editing, graphics, examples, definitions or illustrations meant to render text more comprehensible, the document is written primarily in the language of DOE management. Even though acronyms are explained, the sense of the reasoning used is not readily apparent to users of standard English. Considerable interpretation is required, to make the document and its many concepts comprehensible and, therefore, capable of analysis and discussion by members of the public .

Further, the CEQ requires that the DOE use facilities that are local to any affected sub-population. This would mean holding meetings in the neighborhoods of any such affected populations. In Clark County, these meetings have been held at Cashman Field or in the adjacent State of Nevada Sawyer Building, or at UNLV - all easily reached by those with a car and with time for an afternoon or evening meeting. But, in a practical sense, this means that anyone who wants to be heard by the DOE must have the time and the ability to meet at pre-arranged DOE meeting sites, rather than at neighborhood locations more convenient for those people who would be affected by the project.. DOE' attempt at outreach has failed miserably.

We are, therefore, concerned that DOE made no substantial effort to reach the people who would be most affected by the Yucca Mountain project. To counter this deficiency in outreach, from October 1999 through January 2000, Clark County NWD staff presented information about the DEIS at more than 20 public meetings in Clark County and to a large number of individuals. Almost without exception, we were asked why DOE wasn't doing more to directly inform the public about the DEIS?

In DEIS Section 1.5.1, DOE indicated that during the scoping process, they invited members of the general public to participate in the process. The Department mailed a series of information releases to Yucca Mountain stakeholders and members of the public notifying them of the opportunity to comment. However, there is no indication of the number of members of the general public or which groups were sent the information.

56 cont. Section 1.5.1 further noted that during the scoping process, DOE "...submitted press releases and public service announcements to newspapers and television and radio stations; ..." Again, there is no indication regarding which newspapers or television and radio stations were notified. There is no indication that DOE made any attempt to encourage public involvement during the public comment period on the DEIS.

There is also no description of any efforts made to contact the public about the DEIS during the comment period. With a project as important as the Yucca Mountain Program, one that may affect generations of Nevadans, it would have been in the spirit of NEPA to broadly disseminate advertisements, in addition to public service announcements on radio and television. Public service announcements and press releases often only reach a small proportion of the population. Public service announcements, generally, compete for a limited amount of airtime with other community events. There is indeed no guarantee that they will be given any airtime or not relegated to off prime time scheduling. DOE has in fact violated its own Environmental Justice Strategy objectives that require DOE not only to use public service announcements, but also radio, TV, and minority publications to advertise forthcoming hearings or meetings.

One example of the inadequacy of DOE's public information process occurred at the Salt Lake City DEIS public hearing on January 13, 2000. In the entire State of Utah, notice was published only in the Salt Lake Tribune. However, there is another major Salt Lake City newspaper, the Deseret News, which attracts a large, separate readership. As a result, many residents were unaware of the public hearing. It should be noted that there are also a number of other papers in Utah serving major population centers in the Ogden and Provo/Orem areas as well as other cities along potential transportation routes throughout Utah. The poor turnout of citizens at the Salt Lake public hearing is indicative of the meeting notification not being well publicized.

In summary, DOE did not demonstrate that they met the federal requirements to "make diligent efforts to involve the public" in the NEPA process. It appears that DOE has performed the bare in public involvement. Considering that the Yucca Mountain Program could impact a sizable segment of the nation now and for many future generations, more effort should have been made to ensure that those "*who may be interested or affected*" would know about the DEIS, how it could affect them and how they could participate in the public process.

2.4 Environmental Justice: Effects Upon and Inclusion of Low-Income, Minority Groups and Native Americans in the DEIS Process

Primary Reference: DEIS Chapter 2; Appendix J

57... In 1998, the population of Clark County was just about 1.2 million, with 13% described as Hispanic, 9% African American, 5% Asian/Pacific Islander, and about 1% Native American. Most of the latter live on one of two reservations located in the county.[2] As of July 1999, there were an estimated 35,610 non-English speaking or reading people in Clark County, almost 5% of the population. More than 75% of these, approximately 26,990 people, speak and read only Spanish. Approximately 15% of County households may be classified as low income. The Clark County population also consists of retired persons, generally older than the median county age of 47 years, and who usually live on a fixed income below the median county income of about $40,000 per year.[3]

Clark County's analysis of the laws, regulations, executive orders, agency guidelines and other government documents confirms that there are two underlying concerns regarding environmental justice.[4] The first is that the safety of populations most vulnerable to government actions with potential adverse environmental impacts should be given special attention and deserve protection. The second is that the groups most affected by government actions should participate in the decision-making processes. These can more succinctly be referred to as concerns about vulnerable populations and public participation. These two concerns correspond with the working definition of environmental justice used by Clark County for purposes of these comments:

> "a social condition in which environmental hazards, particularly those created by human actions, do not disproportionately impact vulnerable individuals and populations, and in which decision-making

57 cont. processes concerning the distribution of these impacts are safeguarded against unjust outcomes by a range of policies and practices."[3]

Clark County's review of DEIS Appendix C reveals that DOE did not meet the requirements of Executive Order 12898 that directs DOE to consult with states, Native American tribes and local governments to identify minority and low-income groups within their jurisdictions. Clear identification of such groups would allow DOE to provide proper notification regarding the EIS meetings, provide translations of materials, and otherwise encourage individuals and organizations that represent these groups to participate fully in the process. However, no such consultation occurred between DOE and Clark County. This raises the question whether there were any real efforts to get input from Native Americans, low-income, minority, non-English speaking and others who live along the likely transportation routes and who have claims to Yucca Mountain and surrounding land.

The interpretation of environmental justice issues are dependent upon the findings of the DEIS. The DEIS concludes that no harm would occur to these vulnerable populations. Given that a substantial number of minority and low-income populations reside along proposed transportation, DOE does not substantiate this lack of risk in the DEIS. Within this context, we present our comments on the environmental justice aspects of the DEIS.

2.4.1 Effects on Environmental Justice of Inadequate Methodology and Outdated Information

58 In the DEIS minority and low-income populations are identified along possible transportation routes and in the vicinity of the proposed disposal site for the high-level nuclear wastes. This is accomplished by identifying census tracts and determining whether the proportion of these groups within those census tracts is higher than in other tracts. Because in the Yucca Mountain DEIS it is concluded that there is very little or no risk of adverse impacts from the government actions in question, it is also concluded that these groups will not be significantly affected.

There are several inadequacies in the methods that lead to these conclusions. These are listed below along with corresponding recommendations.

The DEIS treats minority and low-income populations as the vulnerable populations of interest (DEIS, pg. 3-94). These groups are specifically mentioned in all government documents considering environmental justice, because they have historically been politically vulnerable to government actions with adverse effects. But these are not the only groups that are disproportionately vulnerable to such actions. Guidance documents for interpreting Executive Order 12898 emphasize that fair treatment means that no group of people should bear a disproportionate share of negative environmental consequences of government actions. Other groups, for example, would be disproportionately vulnerable to such consequences because of impaired health or immature immunological systems.[5]

In view of this, we recommend that other vulnerable populations, including the aged, the infirm, pregnant women, and children, be included in the DEIS and other environmental justice analyses.

The DEIS sections on environmental justice use census and demographic information from 1990 (pp. 3-94, 3-96). The population of Clark County has changed dramatically in the ten years since the 1990 census. The Council on Environmental Quality (CEQ) Final Guidance Document notes the limitations of census data and proposes using multiple sources of information on potentially affected populations.[6] Clark County recommends that data on current populations and projections of population changes into the foreseeable future should be used to correct, supplement or replace 1990 Census data.

2.4.2. *Religious-Cultural Impacts to Native Americans*

59 Native Americans are included within the explicit definition of "minorities" in all government documents referencing environmental justice, and most can also be included in the definition of "low-income." Adverse religious-cultural impacts to Native American tribes in the vicinity of Yucca Mountain from activities related to the proposed repository are acknowledged as an unresolved area of controversy in the Yucca Mountain DEIS (pp. S-65, 4-84, 4-85). It is unclear then why this is referred to as an area of controversy rather than as a violation of environmental justice. In addition, the DEIS does not consider the cumulative cultural impacts to Native American tribes from other government activities as well as the Yucca Mountain project, such as activities related to the Nevada Test Site. Furthermore, in addition to other potential impacts, the DEIS does not consider the adverse impact of the proposed repository on the potential economic development of these communities.

Clark County recommends that DOE state and provide rationale for the statement that adverse religious-cultural impacts to Native Americans are regarded as controversial rather than a violation of environmental justice provisions. DOE should also analyze the cumulative impact on the cultural interests of Native American tribes of all government activities in the vicinity, including the Nevada Test Site and consider the adverse impact of the proposed repository on the potential economic development of tribal communities.

2.4.3. *Effects on Environmental Justice of the Conclusion of No Significant Adverse Impacts*

60 In DEIS Section 5.2.4.1, it was first stated that population changes could significantly alter the risks, but the DEIS immediately found it acceptable to simply use present and past demographic information for assessing risk. This is a significant problem since the exclusion of socio-demographic modeling comes subsequent to the observation on p. 5-17 that "...forecasts are valuable in the decision-making process..." That is, they have limited their forecasts to those derived through geological, hydrological or radiological modeling -- technical issues, while at the same time ignoring the facts that:

[1] For environmental justice concerns (and health/safety risks generally), what matters is the nature of the populations at the times when the repository is under construction and in operation, and after post-closure, and;

[2] Socio-demographic forecast modeling is a basic analytical tool used by regional planning agencies and zoning boards everywhere, probably no more or less prone to uncertainty than technical and engineering models.

In Clark County, growth assessment/planning issues are highly visible and energetically studied, and used for strategic and short-term planning. We believe that DOE must forecast likely growth patterns and attributes, and discuss their potential implications for Yucca Mountain repository risks and impacts.

2.4.4 *Environmental Justice and Future Generations*

61 In NWPA Section 10131, future generations must be made a priority in studying the potential effects of the repository. Yet, the DEIS does not discuss this issue anywhere. We urge DOE to require or permit serious discussion of the obligations owed to future generations from nuclear waste management activities.

2.4.5 *Clark County Comments and NEPA Citations Regarding Specific DEIS Statements: Environmental Justice*

62... **DEIS Statement** - DEIS Table 2-7, pg. 2-76, *Impacts Associated with the Proposed Action and No-Action Alternatives*

Clark County Comment - Does DOE intend to fund the protection of cultural resources exposed to risk under the proposed action? DOE should also explain in detail the differing view of the Native Americans as to

62 cont. impacts from nuclear waste transportation. It is insufficient to refer to the concerns of Native Americans as occurring solely with reference to the cultural resource impacts.

63 **DEIS Statement** - Table 2-7, *Impacts Associated with the Proposed Action and No-Action Alternatives*, pg. 2-78 in the DEIS

Clark County Comment - There is no basis for the conclusion that there would be no environmental justice impacts from the proposed action, since the DEIS used a faulty methodology and failed to look at impacts at varying scales. *NEPA Regulation: Sec. 1502.16 Environmental consequences*

64 **DEIS Statement** – DEIS Table 2-9, pg. 2-83 and 2-85, *Comparison of Impacts for Nevada Heavy-Haul Truck Implementing Alternatives and for legal-weight Truck Shipments.*

Clark County Comment - The DEIS does not examine impacts at a scale where potential environmental justice impacts where they could be assessed. This ignores the reality of poor and minority communities that are frequently concentrated in pockets near major transportation corridors for both rail and legal-weight truck. *NEPA Regulation: Sec. 1502.16 Environmental consequences; Executive Order 12898.*

65 **DEIS Statement (pg. 6-15) 6.1.2.12** - DOE does not expect disproportionately high and adverse impacts to minority or low-income populations from the Proposed Action. The environmental justice analysis involved a two-stage assessment of the potential for disproportionately high and adverse impacts on minority and low-income populations:

First, a review of the activities included in the Proposed Action to determine if they would be likely to result in high and adverse human health impacts or in environmental impacts that could affect human populations. Second, if the first stage review identified high and adverse impacts to human populations in general, an analysis of these impacts as described above to determine if they could be disproportionately high and adverse for minority or low-income populations.

If the first-stage review does not identify impacts to human populations, a second-stage analysis for potential environmental justice impacts is not required because there would not be high and adverse impacts to any part of the human population, including minority and low-income populations.

Clark County Comment - The two-step procedure used to determine environmental justice impacts is inappropriate. This method potentially masks significant impacts to minorities and the poor. It is very possible that even a small number of incidents could be disproportionately distributed among these groups. The analytical method for determining environmental justice impacts should not be dependent on demonstrating an impact to the general population. The term "disproportionately" also needs to be defined.

66 Cumulative impacts throughout the DEIS are not readily identified given that the procedures used to define impacts are not sufficiently sensitive to isolate impacts among subgroups. With the methodologies **(X)** available today to analyze data, and given the unprecedented nature of DOE's proposal to ship large volumes of nuclear waste across the nation, it is reasonable to expect DOE to analyze potential impacts at a variety of scales.**(X)** Without such detail, neither Clark County nor communities along the transportation routes will be able to effectively assess impacts and design appropriate mitigation strategies. *NEPA Regulation: Sec. 1502.14 Alternatives including the proposed action; Sec. 1502.16 Environmental consequences; Sec. 1502.22 Incomplete or unavailable information. Forty Most Asked Questions Concerning CEQ's NEPA Regulations. 19a. Mitigation Measures.*

2.5 Cumulative Impacts

Primary Reference: DEIS, Chapter 8

Citing NEPA regulation, 1508.7, "cumulative impact" is the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

2.5.1. Cumulative Impacts Related to Transportation

67 In Chapter 8, the DEIS has understated the scale and complexity of the cumulative impacts of DOE programs for the simultaneous disposal of low-level and high-level radioactive waste. According to *DOE's Draft Waste Management Programmatic EIS*[7] and later documents, the Nevada Test Site (NTS) is a preferred regional disposal site for low-level radioactive waste. This program will occur over a number of years, and would greatly increase the total number of truck shipments of radioactive waste through southern Nevada. Under present regulation, these shipments may be routed on the same highway system through Clark County as the shipments to a Yucca Mountain repository.

Despite assurances in the programmatic EIS, the Yucca Mountain DEIS did not contain an authoritative examination of the cumulative impacts of both DOE disposal programs on Nevada and Clark County. According to some estimates, the shipment of low-level radioactive waste from DOE defense sites across the nation to the NTS will last for approximately 70 years. The waste will be shipped by truck, conceivably through the most densely populated and sensitive parts of Clark County. The low-level radioactive waste (LLW) shipping campaign could result in the transport of up to 12 truckloads per day for more than 70 years.

68 The DOE has already established a poor record for managing and transporting LLW in Clark County. For example, after an incident with a LLW highway shipment from Ohio to the NTS that was found to be leaking non-radioactive water, the shipping campaign was suspended for over eighteen months as an internal investigation[8] was conducted. The two major findings were that DOE had not enforced its own requirements regarding the fabrication and deployment of the containers, and that institutional processes between and among DOE facilities, the State of Nevada, local governments and others had failed to provide effective control of this and similar situations.

Another example is regarding DOE's statements and subsequent efforts to minimize risk and impacts of LLW shipments on Clark County. In this case, representatives of DOE Nevada acknowledged that there are administrative means that may be used by DOE to assure that LLW shipments avoid high-risk areas. However, later inaction by DOE resulted in the continuation of shipments through the areas of concern in the Las Vegas Valley, except for truckers that voluntarily used other routes.

69 The DEIS analysis of cumulative impacts shows no consideration of the context in which spent nuclear fuel (SNF) will be transported to Yucca Mountain. There is also no information about other hazardous commodities on the roads and railways. There is no discussion of the substantial impacts of the DOE's LLW disposal program on Clark County and the likely relationship between the LLW and SNF disposal programs.

The DEIS also does not present a description of the impacts of these programs on the infrastructure (e.g., highways, roadside facilities) of Clark County, nor does it provide sufficient information about the necessary emergency management requirements to respond to the DOE's programs. To rectify the substantial omissions in the DEIS, the DOE must prepare a supplemental evaluation of cumulative impacts that describes the current context in which SNF will be transported. This additional analysis must address the current hazardous materials shipments in urban Clark County and rural Nevada for both rail and truck modes, it must describe the process used to identify and measure cumulative impacts and it must measure those impacts.

2.5.2. Cumulative Impacts Related to the Yucca Mountain Site

According to the DEIS, the implementation of Module 1 or 2 would be the only actions that could result in cumulative impacts on cultural resources in the area of Yucca Mountain. These impacts have to do with the potential for illicit or incidental vandalism of archaeological or historic sites and artifacts as a result of increased activities in the repository area.

With regard to socioeconomic impacts, the DEIS stated that no substantial cumulative effects would occur in Clark, Lincoln or Nye counties. This is because, in an example of a cumulative effect as defined by DOE, peak employment at the NTS under various waste management scenarios would occur earlier than that for the Yucca Mountain program. Thus, the affected communities would have more time to assimilate any new residents that relocated to the region.

70 In the paragraphs below, citations are provided from the DEIS regarding its analysis of cumulative impacts on cultural resources and socioeconomic conditions. These are included to demonstrate that, in non-compliance with *NEPA Regulation, Section 1502.22,* DOE has not provided sufficient detail to analyze potential cumulative impacts resulting from the proposed repository at Yucca Mountain. Because of this deficiency, the DEIS inadequately addressed potential mitigation needs.

DEIS Statement, p. 8-37*: Cumulative Impacts on Cultural Resources.* "...the emplacement of either module would require small additional disturbances to land in areas already surveyed during site characterization activities. Because repository construction, operation and monitoring, and closure would be Federal actions, DOE would identify and evaluate cultural resources, as required by Section 106 of the National Historic Preservation Act, and would take appropriate measures to avoid or mitigate adverse impacts to such resources. As a consequence, archaeological information gathered from artifact retrieval during land disturbance would contribute additional cultural resources information to the regional database for understanding past human occupation and use of the land. However, there would be a potential for illicit or incidental vandalism of archaeological or historic sites and artifacts as a result of increased activities in the repository area, which would be extended for Module 1 or 2, and this could contribute to an overall loss of regional cultural resources information.

"The Native American view of resource management and preservation is holistic in the definition of cultural resources, incorporating all elements of the natural and physical environment in an interrelated context (AIWS 1998, all). The Native American perspective on cultural resources is further discussed in Chapter 3, Section 3.1.6. Potential impacts resulting from the Proposed Action described in Chapter 4, Section 4.1.5, would also apply to Inventory Module 1 or 2."

DEIS Statement, p. 8-39: ***Cumulative Impacts on Socioeconomic Conditions.*** "The *Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE 1996f, all) presents various scenarios for Nevada Test Site actions. The Record of Decision for that EIS states that DOE would implement a combination of three alternatives: Expanded Use, No Action (continue operations at current levels) regarding mixed and low-level radioactive waste management, and Alternate Use of Withdrawn Lands regarding public education (61 FR 65551, December 13, 1996). . Under this combination of alternatives, the Nevada Test Site could generate an increase of approximately 4,550 direct jobs, and most of these workers would be likely to live in Clark County (Department of Energy 1996f, page 5-17)."

REFERENCES

[1] Council on Environmental Quality Guidelines, p. 29

[2]The Center for Business and Economic Research, University of Nevada, Las Vegas. *We, the Southern Nevadans.* 1999.

[3] *1999 Las Vegas Perspective.* Nevada Development Authority, April 1999.

[4] Walton, C., A. Zundel, R. Gladd, N. Gott, M. Manning Whittaker, E. Dixon, W. Fowler, P. King, N. Koon-Howard, K. Lauckner, M. Morris, and D. Nick. *Environmental Justice in the DOE Yucca Mountain DEIS.* University of Nevada, Las Vegas, January 2000.

[5] Section 2.1, *CEQ Final Guidance for Incorporating Environmental Justice Concerns in EPA's NEPA Compliance Analyses*, April 1998.
[6] Section 5.1, *CEQ Final Guidance for Incorporating Environmental Justice Concerns in EPA's NEPA Compliance Analyses*, April 1998.
[7] U.S. Department of Energy. *Draft Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage and Disposal of Radioactive and Hazardous Waste*, DOE/EIS-0200-D. 1995.
[8] U.S. Department of Energy Fernald Environmental Management Project. *Type B Accident Investigation Board Report of the December 15, 1997, Leakage of Waste Containers Near Kingman, Arizona*. February 1998.

3.0 IMPACTS OF IMPORTANCE TO CLARK COUNTY NOT CONSIDERED IN THE DEIS

Primary Reference: DEIS Chapters 1, 3, 6

Major Points of This Chapter:

- This section addresses a number of impact areas of importance to Clark County not considered by DOE. If these areas are not addressed in sufficient detail and scope, a meaningful understanding of potential impacts may not take place, and mitigation planning and negotiation strategies not occur. A number of examples are provided to illustrate potential impacts from Yucca Mountain activities.
- The studies summarized in this section demonstrate that there are a number of potential impacts that could be adverse to Clark County residents, visitors, and businesses, harm the quality of life of residents and adversely affect the economic well-being of the County and State.
- A major objective of Clark County government is to sustain the economic strength and vibrancy of our area. This includes commitments to securing a strong economic base for its residents, managing its rapid growth, assuring healthy communities and opportunities for its residents, and preserving the natural environment.
- The DEIS does not consider "stigma induced" impacts. As an example, there exists substantial evidence that demonstrates the real potential for serious property value declines and disinvestment from similar programs. Data indicate that stigma induced changes can occur even under incident-free transportation conditions. At a minimum, stigma-induced impacts if present can result in diminution of property values and business performance, development and investment along routes, and decreases in tourism.

3.1 Introduction

The comments in this section provide an opportunity for Clark County to discuss a number of issues crucial in evaluating impacts to individuals, families, businesses, government institutions, the natural environment and
71 other aspects of our community fabric. If the repository program is approved, Clark County and its incorporated municipalities may be vulnerable to significant adverse effects that could be long lasting. As examples, declines in residential and commercial property values along shipment routes, potential losses in the visitor-tourist sector; and significant declines in many aspects of quality of life are all issues to which Clark County must be sensitive.. Even without accidental releases of radioactivity evidence exists that Clark County residents, not to mention the millions of visitors to Las Vegas annually, could experience a number of adverse affects that are not adequately addressed in the DEIS

72 In Section 1.0, it was stressed that local impacts not be addressed adequately in the EIS and in other federal documents may not be considered substantively to enable mitigation or other assistance should the project proceed. It was also noted that local government decision-makers and the public must consider information relevant to making day-to-day decisions regarding the well-being of their constituencies. The basic criterion of this process may be stated as follows, "Is a program or its immediate and long-term impacts on situations important to us more likely than not to happen? If so, what must we do to avoid or mitigate any harmful effects or take advantage of positive effects?" This will take place whether a road is being constructed or from the transport of nuclear waste. This background is provided to further substantiate the need to consider these potential impacts in the DEIS.

Over the last decade, Clark County and others have examined potential effects that may be experienced by

Clark County residents and businesses because of nuclear waste transportation, the extent of those effects, and the potential short and long-term impacts on the area. This research provides an important summary of possible and anticipated impacts from repository program activities.

With regard to socioeconomic issues, we will present information that documents the relationship between property value decline and stigma that has occurred in other areas and may result from the proposed repository activities. Next, we will present an analysis that shows that the repository would have a significant negative impact on the Clark County's tourism and convention trade. Additional information will be presented regarding special effects, including governmental fiscal impacts, economic development impacts, and business impacts resulting from DOE's proposed actions. We will then briefly discuss the potential effects on the quality of life of Clark County residents that may be attributed to the siting of a HLW repository so close to their communities.

73 Clark County is committed to securing a strong economic base for its residents, managing its rapid growth to assure healthy communities and opportunities for all its citizens, and preserving the natural environment. The concern for economic viability, environmental quality, and social well-being are reflected in quality of life indicator surveys started in 1995 and followed up in yearly polls.[1]

In order to adequately assess potential impacts from this program, it is important that DOE take these concerns seriously – to review these findings or conduct independent analyses, or both, so that a revised DEIS or Final EIS may show a realistic picture of the potential impacts and concerns of Clark County.

In this section, we will also provide the context for this analysis - the sustainability of the Clark County community. The "sustainability" discussion is taken from a well-documented contractor report[2] prepared for the Clark County Nuclear Waste Division in 1999 [the "UER Report"]. Rather than provide footnotes for each discussion point in these comments, we will indicate which aspects are based on findings of the UER Report.

3.2 The Context of Community Sustainability

74... Clark County is joining cities and counties around the country who are starting to define a vision for their future that balances community economic, environment and social well being in order to improve the quality of life of its residents. These "sustainable" communities have developed specific goals and strategies to guide programs and governmental services to achieve this balance and quality of life for the long-term. The goals and visions of these local areas are based on the *values* and *priorities* of residents who live there.

A 1999 report by the White House[3] argues that the real challenge that the nation faces in the 21st Century is to build "livable cities." This involves enhancing economic growth, public safety, environmental quality, well-being of families, and sense of community. As part of a national initiative, 70% of over 200 communities in the U.S. adopted policies to pursue "livable cities." Building on the work of the Community Empowerment Board and the President's Council on Sustainable Development, the Livable Communities Initiative mobilized 12 federal agencies to provide information, tools and monitoring support for community targeted assistance.

From the Federal perspective, the initiative is to broaden choices available to communities in order to sustain prosperity and expand economic opportunity, enhance quality of life, and build a strong sense of community. As part of the Livable Communities Agenda, the federal government has a set of principles that argues that the:

(1) decisions of how communities grow should be made by the communities themselves;
(2) appropriate role of the federal government is to inform and assist, not to direct; and,
(3) federal government should help provide information and tools to help communities anticipate and scope patterns of growth.

These initiatives base their efforts on earlier goals of sustainable development - environmental protection (reduce environmental threats), economic security (build on past investment in communities and broaden the economic base), and social well-being (encourage opportunities for all segments of society).

74 cont. In effect, these initiatives and goals reflect the national policy set forth in 1969 with the adoption of NEPA. The purpose of the act was to:

- Declare a national policy which will encourage productive and enjoyable harmony between man and his environment;
- Promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man;
- Enrich the understanding of the ecological systems and natural resources important to the Nation; and,.
- Establish a Council on Environmental Quality [CEQ] (NEPA, 42 USC § 4321).

While the language of the statute is very short and general, Congress intended in NEPA to:

To use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans (NEPA, 42 USC § 4331(a)).

Clearly, NEPA has resulted in implementation of federal assistance programs to maintain and sustain livable communities. CEQ regulations require federal agencies to comply with the purpose, policy and mandates of NEPA in their planning processes, including the preparation of environmental impact statements and other procedural requirements.

It appears that DOE's proposed repository program with its present insensitivity to local issues is actually working against federal environmental. It is imperative that DOE assure that the Yucca Mountain Program and the description of potential effects from its actions is consistent with national environmental policies.

3.3 Repository Effects on Property Values and Other Socio-Economic Factors

3.3.1 Introduction

75... The potential for impact on property values is clearly emerging as a possible critical impact area for local residents and jurisdictions to consider. In the DEIS, however, DOE avoids discussion of these possible impacts, despite a considerable body of case law and studies that demonstrate the potential exists for serious property value declines and disinvestment. DOE's approach solely relies on probabilistic risk analysis methodologies to demonstrate minimal impacts from transportation accidents. The consideration of these potential other impacts is avoided.

The case for stigma-induced impacts on property values is compelling. One study by DOE of a recent spent fuel transport route designation demonstrated actual diminution effects in a residential housing market. Several important court decisions also have supported property value damages due to perceived risks. Regarding an important case decided by the New Mexico Supreme Court, a survey on which the conclusions of the case were based, show *expectations* of property value declines and designated bypass routes have resulted in losses in property values.

Risk perception surveys considering the potential transportation of nuclear waste scenarios in Clark County reveal substantial public concerns about negative effects from the transportation of nuclear waste. Considerable evidence supports the proposition that property value impacts will occur as a result of designating routes for shipping nuclear waste and that these effects will become more serious with actual shipments. These economic vulnerabilities must be considered for Clark County as part of the DOE's impact assessment process.

In these comments, we will provide that economic and market conditions can change as a consequence of stigma-induced perceptions resulting from the transportation of nuclear waste. The case is built on four research areas:

1. Analogous case experiences showing diminution effects in home and land values as a result of risk

75 cont.

perception regarding hazardous facilities and events;
2. Case law demonstrating the move toward compensating damages from stigmatized places;
3. Surveys of people's perceptions of the risk of transporting nuclear waste and how this type of transport engenders stigma and expectations of losses in property values; and
4. Demonstration of losses in a case of actual shipments.

76... Because of the transfer of transuranic wastes to the WIPP site in New Mexico, the transportation issue received considerable attention, especially in the area of stigma-inducing effects. The studies on public response to WIPP-bound shipments are strongly consistent in their findings and show the potential for serious economic repercussions. Large segments of the public hold high-risk perceptions of nuclear waste shipments and view routes on which wastes will be transported as unsafe and properties near them as undesirable. In an important legal case, public concern over stigma resulting in value loss was compensated despite low objective risks. The New Mexico Supreme Court upheld damage claims due to stigma effects.

Though inconsistent findings exist on diminution effects on property from stigma perceptions associated with hazardous facilities, contaminated areas, and nuclear power plants, a large number of studies also show strong associations among risk perceptions, stigma, and property values. These are consistent with respect to the case of nuclear waste transportation.

There is evidence from national polls and surveys in Clark County showing that the public is concerned about nuclear waste routes and expressed intentions to avoid risks from such transportation. Results from polls indicate that a large percentage of the public is not willing to live adjacent or purchase homes and businesses near these routes. The public feels that areas adjacent to shipment routes will not only be unsafe but will become stigmatized as undesirable areas. The public *expects* that property values near these routes will decline. Property value impacts have already been observed where nuclear waste shipments have been imminent and in one case where shipments took place. Several studies have reported on the negative imagery associated with nuclear waste transportation.

Predicting the size of stigma-induced economic change is difficult, but the data demonstrate that significant stigma-induced changes (e.g., decline in the likelihood of investment) could occur, even under minimal or benign transportation risk conditions. Clark County is particularly vulnerable to these effects and should consider not only the conditions under which stigma-induced impacts will occur, but also the particular sensitivities of various economic sectors to these effects. Moreover, if the nuclear repository program moves forward, local communities will need to consider examining the conditions under which stigma-type effects can be avoided or ameliorated but adverse property value impacts near shipment routes should be anticipated.

3.3.2. Stigma, Property Values and Disinvestment

The public stigmatizes environmental features it views as repellent, upsetting, disruptive, or hazardous. The source of environmental stigma can range from an increased awareness of the incidence of environmental health problems in an area, to concern over the declining market price of properties due to potential harms or from an exodus of residents from a contaminated area.

The possibility of transporting nuclear waste through heavily populated Clark County, Nevada, as evidenced by the substantial number of potential nuclear waste transportation alternatives noted in the DEIS, continues to be particularly troubling in terms of people's concern over health and safety risks. The potential for accidents and their effects on losses in property values near designated or possibly designated routes for HLW transport are also cause for public concern. In this section, we will review studies that will document potential vulnerabilities that Clark County needs to consider from stigma effects.

The existing studies on this topic show that the occurrence of stigma-type effects can adversely impact property values, even without accidents. Therefore, this is a critical issue for the county to consider when planning for

76 cont. and negotiating mitigation programs to remediate the socio-economic impacts that are likely to result from the proposed repository transportation program.

The potential for stigma and the characteristics of stigma-induced effects have been discussed by a number of authorities in risk assessment [Specific references are found in the UER Report, cited in Section 3.1, above, and available at the Clark County Nuclear Waste Division office]. Four factors have been identified as likely causes of property value loss related to stigma under conditions of environmental contamination:

Fear of Public Liability	degree of stigma related to future marketability or liability;
Fear of Hidden Clean-Up Costs	difficulty in assuring buyers that estimated clean-up costs are adequate;
Lack of Financing	inability to obtain financing for the purchase of a property or its future development; and,
Fear of Accidents or Future Harms	related to the proximity to the source of danger and desire to reduce the risk.

There are a number of studies that demonstrate the public's strong belief that property values near spent fuel shipment routes are expected to decline. This is an important factor to consider when evaluating impacts to Clark County. First, if such attitudes are prevalent and strongly held, investors will shy away from areas near potential routes for investment or development purposes. Second, property value declines may occur prior to actual shipments and without incidents when shipments do occur. Third, nuclear related transportation accidents with or without releases of radioactive materials may cause serious and long-term adverse impacts to property values.

A University of Nevada, Las Vegas (UNLV) national survey of public reactions to nuclear waste shipments supports a case for stigma-induced effects.[4] The specific intent of this national survey of 1,012 persons was to evaluate the extent of which public reactions to nuclear waste shipments would impact the willingness to purchase property near nuclear waste routes. Approximately 68% indicated that they would be unlikely to buy a house in the immediate area of a highway or rail corridor that shipped spent fuel.

The study also reported that 63% of the national sample would likely move away from an area where nuclear waste is transported. When asked about the minimum number of miles from a nuclear waste transport route that they would find acceptable to live, 21% indicated a distance of five miles or less, 23% indicated between six and 25 miles, and the remaining 56% more than 25 miles. This study suggests important behavioral expectations from shipping nuclear materials, including declines in property purchases and out migration from these areas based on nearness to these routes.

In a study on attitudes of recent homebuyers in the Las Vegas area, relationships were found between the proximity to possible nuclear waste transportation routes and home buying preferences.[4] For homebuyers who were unaware of the repository, 61% placed "substantial importance" on the proximity of their new homes to a nuclear waste transportation route. When home buyers were asked how close would they be willing to live to a nuclear waste transportation route, 6% indicated one mile or less, 4% between one to three miles, and 90% over three miles.

In many cases where environmental damage is likely to occur but has not been detected, the possibility alone of future declines in property values may inhibit purchases resulting in losses in market value. An examination of several properties that were only mildly contaminated or suspected of contamination found that the marketability of such properties was limited by various economic fears. These fears include higher financing costs because fewer lenders were willing to consider these properties.

The literature on property values has proliferated during the last ten years with cases demonstrating diminution effects resulting from public perceptions of the risk of contaminated sites, facilities, or accidents involving the release of hazardous materials. The relationship between property value declines and proximity to hazardous

76 cont. facilities, contaminated sites, and shipment routes for hazardous materials is often based on hedonic price theory. This theory maintains that the value of a good will decline in utility because of decreases in environmental amenities. The perception of possible risks or other adverse impacts from a given hazard or site with potential environmental contamination can negatively influence property values because the demand for residential or business location near the site lessens.

It has been shown that risk perceptions can cause a decline in property values. Despite the fact that a landfill in Colorado was closed without apparent adverse health effects, property values declined in areas where there were perceived health risks. Neighborhoods closer to the landfill had larger percentages of people who judged the project to be a high risk one, leading to the conclusion that subjective health risk was the primary factor in causing real estate values to drop around the landfill. According to this finding, changes in property values are real and depend on risk beliefs that may result from responses other-than-objective risks.

Using the *hedonic pricing method* to measure changes in the real estate market near the site, actual prices have been compared to changes in the neighborhood collective risk judgment. For each 10% increase in the proportion of households in the high-risk group (those who believed the landfill posed a high risk), home prices in that neighborhood decreased $2,084 on average.

Property value declines have been found to result from perceived harms. For example, several researchers have suggested that waste facilities can create negative images of danger that have the potential to stigmatize an area's attractiveness for residential location or investment. In fact, the concern over the potential for stigma to occur because of the location of an unwanted facility or a hazardous waste shipment route could by itself adversely impact investment in the area. Researchers have argued that [1] high levels of perceived risk over potential groundwater contamination from a landfill resulted in serious losses to assessed values of properties near the site, and, [2] the awareness of a low-level radioactive waste site is directly attributable to adverse effects on property values.

Whether the site actually is hazardous is not important. What is relevant is that it is perceived as such and it is the perception of fear associated with the facility that becomes translated into the observed negative effects on property values. For a new waste facility, a negative effect on property values is likely to persist for some time into the future since the effects would have occurred as a result of the creation of a facility as opposed to the discovery of a problem from an existing facility.

These studies have called on the concept of stigma to explain the adverse price impacts of perceived risks. The conclusions support the contention that stigma may affect property values without real or observable contamination.

Further support for property value losses as a result of stigma comes from another study that found changes in the Houston housing market after the EPA disclosed local sites on the National Priorities List - a list of all Superfund sites in the United States. This study indicates that the announcements by EPA and ensuing publicity provoked a change in public perception whereby residents now viewed proximity to a toxic waste site as a disamenity. After the disclosures, housing prices decreased, but at smaller rates the further houses were from the sites, up to a distance of six miles. Interestingly, consumers failed to distinguish among site severity in their market responses and treated all sites as equally contaminated.

Even the cleanup of contaminated sites may have little effect on decreasing housing values. This has been observed even when the property is cleaned up to the full limits of available technology and the contaminants tested below EPA standards. Yet, buyers remain reluctant to purchase property in such an area. Cleanup alone was not observed to eliminate the value loss from perceptions of harm and future liability. Even with cleanup plans, property values near Superfund sites around Boston did not recover. However, there is some evidence that housing prices may rebound over time with cleanup measures. It appears that some diminishing selling

76 cont. prices may recover while others display little change, and there may be price gradients that relate land values to proximity to stigmatized areas.

A 1991 survey of major real estate lenders attempted to quantify lenders' perceptions of environmental risk and the degree to which these perceptions affect underwriting policy. The study found that less than 40% of banks would consider lending on a property contiguous to a parcel that was environmentally contaminated. For properties with potential environmental problems, 66% of the banks would require additional indemnification from the borrower, 46% would consider adjusting the loan-to-value ratio, and 60% would require personal guarantees or some personal liability.

In a survey of changes in expectations of residential and commercial property values associated with nuclear waste transportation on a proposed bypass in Santa Fe County, New Mexico, over 70% of the sample population indicated that properties near the bypass would sell for less than comparable properties farther from the route. In addition, almost 60% indicated that under no conditions would they purchase residential properties near the proposed bypass. Another 20% identified conditions for home purchases including low purchase price, unambiguous demonstration of safety, and other risk reduction assurances. This case demonstrated that compensation was deemed necessary to counteract property-value damages resulting only from public concerns over safety and concerns over the economic impacts from stigma.

A contingent valuation survey of New Mexico residents examined whether people were willing to accept compensation for nuclear shipment routes through their state or whether they would pay to avoid such routes to the Waste Isolation Pilot Project (WIPP) site. The study found that a substantial number of people would reject the routing of such shipments and would require extreme compensation. The results also demonstrate that the closer people are to the proposed transport routes, the more willing they are to pay to avoid shipments of nuclear waste. The most negative valuations of proposed nuclear waste routes are associated with high-risk perceptions, especially among families with children, females, and households close to the proposed routes.

Other surveys have questioned residents about the actual routes proposed to transport nuclear waste. As part of the cleanup of the Hanford Reservation, a nuclear weapons production facility in the State of Washington, the DOE proposed to ship transuranic wastes to the WIPP facility in New Mexico. A survey of residents in four counties in Oregon through which the wastes would be transported revealed that approximately two-thirds of the population expressed serious concerns that nuclear waste shipments would produce harmful health and safety effects in their communities. The public associated negative images with nuclear waste shipments, associating the phrase "nuclear waste transport" with images of "danger."

Residents in the survey also believed that these shipments would cause adverse impacts on business development and other economic activities in areas along the transport route. For example, approximately 65% of the sample "strongly agreed" or "agreed" that such areas would likely be unattractive for tourism and business development. Their concern was that these routes would become stigmatized.

The results of this study suggest that home buying behavior in areas where nuclear waste shipments are proposed is likely to be influenced by proximity to the nuclear waste transportation route. Clearly the location of homes in relation to shipment routes would be important in buying decisions. For most persons, given that they are made aware of nuclear waste shipments, buying a home would be contingent on distances greater than at least three miles from such routes

3.4 Repository Effects on Tourism

3.4.1 Introduction

77... Since 1970, 72% of Nevada's population growth has occurred in Clark County. Over the last decade, the population of Clark County has doubled from 661,900 to over 1.3 million, while Nevada's population has grown from approximately 1.1 million to 1.85 million

77 cont. Since 1980, employment in Clark County has almost tripled, reaching 606,685 in 1998. Total personal income has grown almost six times from $5,217,000,000 to over $30,000,000,000. This growth has been largely fueled by increases in tourist visits that have grown from approximately 12 million visitors to almost 31 million in the same period. The number of visitors to Clark County grew by 3.1% in 1999. This increased gaming revenues by 4.5% in 1999 and a projected 4.9% in 2000.

Gaming revenues provide approximately 42% of the State of Nevada's tax base. This illustrates the continuing dominance of the tourism sector in Clark County's economy. Growth in this dynamic sector has fueled Nevada's population expansion and economic development over the last decade. The 31 million tourists who visited Clark County last year contributed almost $25 billion to the local economy.

Sustaining the health of Clark County's tourism economy is critical to both the short and long term economic well being of both Clark County and the state of Nevada. Thus, it is critical to understand the context that links Clark County's tourism market to other regional and national markets. Further, it is important to understand the influence that the proposed repository-related transportation may have on this vital component of the economy. Previous studies have indicated that the tourism industry is particularly sensitive to changes in image, and nuclear waste evokes very strong negative images related to health and safety concerns.

In Clark County the tourism sector can be broken down into various subgroups which include the convention sector, non-gaming tourists, gaming tourists, and those tourists who use Las Vegas as a base for recreating in nearby places. Different internal and external factors as well as imagery influences each sector.

Areas that experience hazardous incidents may become less attractive and/or stigmatized which can negatively impact institutions. There are a number of examples of this phenomenon. A 1990 report in the New York Times highlighted a downturn in tourism that followed a 1990 subway shooting. Similar reductions in tourism were identified in Florida after a spate of tourist attacks. A 1976 outbreak of Legionnaire's Disease so devastated visitor rates at the Bellevue-Stratford Hotel in Philadelphia that it was forced to change its name. When medical wastes washed up on the shores of New York and New Jersey beaches in the summer of 1988, resulting losses to the tourism industry were forecast at $1.5 billion.

In order to measure the impacts that the proposed transport of HLW may have on the local tourism economy, Clark County and the State of Nevada have undertaken a number of studies. These studies and others will be examined in this impact summary. Specific references are contained in the UER Report, cited in Section 3.1.

3.4.2 Analogous Case Studies on Tourism

78... Since the proposed Yucca Mountain repository is unique, there is no history of direct experience of determining impacts from a similar facility on tourism. Data from analogous experiences, however, can be utilized to assess likely impacts to Clark County's tourism from the transportation of nuclear waste to the proposed repository. Facilities and events, however, have been identified that can provide insight about the duration and range of potential impacts. These efforts have focused primarily on the use of case studies. Further, although they isolate the types of impacts that might occur to Clark County because of the repository, they were not designed to measure perceptions of risk and links to fiscal impacts on tourism. The following section will review the key studies that have been conducted of "analogous" impacts.

Nevada Test Site. One of the first studies to measure the potential impacts of the proposed repository on tourism was conducted for DOE in 1985. This study was designed to identify potential impacts from the proposed repository at Yucca Mountain on the tourism industry in Nevada and to identify additional research that was needed to assess these impacts. The basis of this report was the development of brief case studies that the researchers felt were analogous events. For example, they used the rapid economic growth of Las Vegas since 1951 to argue that the Nevada Test Site (NTS) did not have a significant impact on the tourism sector of the economy. However, this study did not attempt to evaluate what type, diversity and size of growth might

78 cont. have occurred in Clark County if the NTS site was not located nearby. In fact, another researcher found that no comprehensive studies have been conducted about the effects of the NTS on the Las Vegas visitor economy.

It has also been shown that that subsequent to media reports about increased leukemia rates linked to the radioactive fallout emanating from the NTS, tourism and convention rates dropped in St. George, Utah. Media reporting on potential health effects of small events related to the transport of nuclear waste may in fact amplify public concerns over health and safety. This could have serious adverse consequences for Clark County's tourism economy.

Additionally, the Nevada Test Site is part of the United States defense establishment. As such, perceptions about its acceptability are linked to values related to national security. In contrast, the Yucca Mountain repository has been proposed to solve a civilian waste problem. Public sentiment about the civilian use of nuclear power is clear. Since 1978, no new nuclear power plants have been ordered in the United States. Numerous studies document the public's opposition to a nuclear waste repository in Nevada and the extreme public concern about nuclear waste has been constant.

Three Mile Island (TMI). Researchers have attempted to analyze the impact of the 1979 accident at the Three-Mile Island (TMI) nuclear power plant near Harrisburg, Pennsylvania, on area tourism. The accident at TMI involved concerns over the release of radiation that amplified an already growing level of concern about nuclear power in general.

The analysis was based on a 1980 report prepared by the Commonwealth of Pennsylvania that found that in a 6-county area surrounding TMI that the convention and lodging industry suffered losses of $5.0 million in the period just after the accident. The Commonwealth of Pennsylvania claimed that the reason for the downturn was "uncertain" and could have been the result of other factors including a slowdown in the economy, a gasoline shortage, and a local polio scare. The report also indicated that a survey of potential tourists found that 6% intended to avoid traveling to the Harrisburg area in the summer of 1979.

The study argued that the accident at TMI may have actually resulted in an increase in tourism to the area because the reported visits to the TMI visitor's center went up in the two years subsequent to the accident. Additionally, they argued that local business leaders had indicated to Commonwealth of Pennsylvania representatives that tourism "approached or attained" pre-TMI levels within one year after the accident.

What the report does not point out is that there was no long-term monitoring of the tourism impacts of the TMI accident. In fact, much of the report is anecdotal comment by representatives of the tourist industry who certainly did not want to stoke the negative press that accompanied the TMI accident.

Nuclear Power Plants. An NRC-sponsored study measured the impacts on tourism in Massachusetts, Florida, and New Jersey from a proposal to site floating nuclear power plants off the coast of a beach community. It was found that 23% to 27% of those interviewed stated that they would not return if a floating nuclear power plant were stationed offshore. This study also indicated that the level of impact decreased with distance from the proposed facilities. In a summary report of these findings, it was suggested that actual avoidance rates would likely be lower than those indicated by the survey.

In another study, it was shown that the rate of beach visits to State Parks in areas near three nuclear power plants in three states decreased in the period immediately after the plants came online. In the five years following nuclear power plants coming online, at Illinois Beach State Park, near the Zion nuclear power plant and Rocky Neck State Park, near Millstone, Connecticut, visitor rates remained below pre-plant commencement levels. Attendance at San Clemente State Park, California that had grown rapidly in the period immediately prior to the opening of the San Onofre nuclear power plant declined immediately after operations at the plant commenced.

78 cont. These studies may not be directly analogous to the potential impacts of the proposed Yucca Mountain repository on Clark County's tourism sector since they focus on tourism based on a natural resource, i.e. a beach. In addition, the studies also are not directly associated with nuclear waste transport. However, studies have shown that concerns over nuclear waste transportation are far higher than those for other nuclear related factors. Thus, the studies cited here do support the contention that the tourism industry may be vulnerable for varying periods as the result of the nearby siting of a nuclear-related facility.

3.4.3 Yucca Mountain Studies

In addition to the analogous events approach described above to identify potential impacts a series of other investigations have been undertaken focused more specifically on the proposed Yucca Mountain's facility's impact on area tourism. These investigations include surveys to elicit behavioral intent, visitor decision modeling and one study that provides a provisional estimate of convention losses.

Eliciting Behavioral Intent. Since 1987, two surveys were conducted to gather information about the public's perception and attitudes towards the proposed repository at Yucca Mountain. One-survey targeted Nevada residents while the other was national in scope. Each was designed to elicit potential behavioral changes if the repository were constructed. The survey questions examined issues related to retirement, family rearing, vacation preferences, convention attendance, and business relocation. The majority of respondents to both the Nevada and national surveys indicated that the repository would adversely impact the attractiveness of Nevada as a retirement area, a place to raise their family, locate a business or vacation. Close to one-half of the respondents also indicated the repository would negatively affect their decisions on attending a convention in Nevada. Again, these adverse impacts on tourism were found even under scenarios without incident.

Another study used a series of scenarios to determine the behavior of Clark County residents under different risk situations. Since it is uncertain how the repository will perform, this approach allows conditional assessments of likely behavior. The study sought to understand how two specific behaviors, outmigration and investments might be affected under a benign incident scenario, a moderate incident scenario and severe incident scenario. Under the benign scenario, 1% of the respondents indicated that their outmigration would increase. This soared to 79% under the severe scenario group. Willingness to invest in business among those who had reported that they "definitely" planned on investing in the local economy was lowered by 63% under the benign scenario and by as much as 76% under the severe scenario. Outmigration and reductions in investment in the local economy could be significantly deleterious to the many small service businesses that support the gaming industry.

A 1988 project surveyed a sub-sector of tourism visitors - convention planners. The survey targeted only those convention planners who had previously selected Las Vegas as a meeting site. Respondents were asked to reconsider their decision to site a convention or meeting under a variety of scenarios from benign to recurring accidents, and under varying media attention from scenarios that downplayed events to those that amplified incidents. This survey indicated that even if the repository ran without incident for 10 years, meeting planners would lower their ranking for conventions of Nevada by 30%. Additionally, 4% would not consider Las Vegas at all. Under a scenario of repeated accidents and amplified media coverage, almost half would not even consider Las Vegas for a convention. This survey clearly supports the contention that even under the most benign risk conditions, the visitor economy in Clark County is likely to be adversely affected by the proposed repository.

To further explore whether the proposed HLW repository program would influence the decision-making of convention attendees, a 1993 survey sampled 600 persons who had previously attended a convention held by one of six associations. They were queried about the factors that influence their decisions in relation to meeting attendance. They were also asked how various noxious facilities located within 100 miles of a meeting site might influence their decision. The noxious facilities included a prison, a nuclear power plant, a hazardous waste incinerator, a low-level radioactive waste repository, and a HLW repository.

78 cont. Respondents indicated that a prison or a nuclear power plant within 100 miles would have only a minimal effect on their decision to attend a convention (less than 3.2%). Waste disposal facilities, however, created significantly more concern. Almost 6.5% indicated that the presence of a hazardous waste incinerator within 100 miles would "definitely" or "probably" negatively affect their decision to attend a convention. This grew to 10% when asked to consider the effect of a low-level radioactive waste facility and to almost one-fourth for a HLW facility. Clearly, the level of effect expressed about the location of a HLW repository was much higher than any other type of noxious facility cited. This indicates that the "analogous event" approach to estimating impacts discussed earlier may not capture the extent of potential impacts of a HLW repository.

Visitor Decision Modeling. Another approach that has been taken to understand potential tourism impacts has been the testing of visitor decision-making. These approaches are based either on risk avoidance or negative imagery. Using the risk avoidance approach, researchers hypothesized that those living near the repository and along the transportation corridors leading to it would attempt to avoid the area if they believed that their health would be adversely affected. As part of the convention attendees' survey discussed above, respondents ranked whether various risk factors were "very important" when deciding whether to attend a convention. Respondents ranked crime rate, natural hazards and environmental hazards as "very important" by 26%, 12%, and 9%, respectively.

The survey results of convention attendees was also used to determine whether their reported concerns were predictive of their actual past behavior and future behavior. Respondents were asked to rank four cities on a series of factors including crime, natural hazards, and environmental hazards. Analysis of these results indicates that they are predictive of actual past conference attendance. For half of the six groups tested, at least one risk factor proved predictive of both past and future meeting attendance. The survey results support the contention that perceptions of risk associated with the transportation of spent fuel and HLW to the proposed repository at Yucca Mountain may translate into risk avoidance behavior that adversely impacts tourism.

In a study of over 3,000 respondents, it was found that an underground nuclear waste repository evoked a predominantly negative image among 40% of the respondents. Another study was done to assess images associated with various cities and states including Denver, Las Vegas, New Mexico and Nevada. Those surveyed were asked to rank the images in terms of positive or negative connotations that they provoked. These scores were than added to produce an image score for each place. These results were found to be positively correlated with identified preference for visiting these locales. Further, a longitudinal survey eighteen months later found that the image scores were predictive of visits to these locales. In similar research, it was found that an image score was "significantly related" to the likelihood that a respondent would actually attend a meeting in a specific city.

These studies indicate that if Las Vegas becomes associated in the public's mind with the proposed repository at Yucca Mountain that any negative incident linked to the repository could adversely influence tourism rates.

Estimating Convention Losses Modeling. In an attempt to address limitations identified with intended behavior research, researchers modified a model that forecasts the propensity of consumers to purchase goods using reported intent. This model was designed to [1] produce a first cut estimation of the proportion that will engage in a specific behavior based on intent, and, [2] measure the degree of bias in expressed intent versus actual behavior. The study indicated that even under the scenario of no incidents during repository construction, 12% to 36% of convention planners would choose somewhere other than Las Vegas to hold a convention. Under the scenario of multiple transportation accidents, the number of convention planners that would choose sites other than Las Vegas grows to between 47% to 80%. While these ranges are quite wide, they do indicate that the repository is likely to have some level of adverse impact on the tourism sector.

Tourism Industry Concerns. The most recent analysis of the potential impact on the areas tourist industry from the transportation of spent fuel and HLW to the proposed Yucca Mountains repository was a 1999 survey of Las Vegas Chamber of Commerce members. The respondents were asked to rank the level of

78 cont. impact on their economy, their business, and themselves under three scenarios related to the transport of spent fuel and other high-level radioactive wastes through Clark County to the repository. The three scenarios described progressively more severe transportation incidents.

Survey results indicate that even under the benign no-incident scenario, 43% of respondents from the tourist industry thought that the impacts would be moderate to significantly adverse on the tourism industry. The second scenario evoked a response of "significant impact" from almost two-thirds of the respondents from the tourist industry. This level of concern grew to 83% under Scenario 3, even though no one was injured and the NRC determined that the level of release was minimal.

These results further the proposition that some level of adverse impact on tourism is possible from the proposed repository. While there is uncertainty as to the performance of the proposed repository that prohibits a specific impact assessment, it is clear that the tourist industry expects that there will be an adverse impact at some level.

3.4.4 Conclusions Regarding Repository Effects on Tourism

To date, none of the studies that have been done can firmly establish the nature and size of adverse impacts to Clark County's tourism industry that may likely be attributed to the proposed Yucca Mountain repository. However, they certainly indicate that adverse impacts may occur even under no incident conditions. This supports the contention by Clark County and the State of Nevada that such impacts must be carefully analyzed and incorporated into any decision process on whether to construct the proposed repository at Yucca Mountain, Nevada. In the face of the growing national competition in the gaming industry, negative images of Las Vegas due to the nuclear waste program could have a highly negative impact on tourism in Clark County. In fact, the Chamber of Commerce survey indicates that business leaders within the tourism industry do expect an adverse impact under the most benign scenario of no incidents.

It is clear from the studies that Clark County's tourism industry is highly vulnerable to the proposed nuclear waste repository and, especially, the transportation of nuclear waste through the Clark County. The convention visitor economy is particularly sensitive to images of place and the repository evokes seriously negative images. The studies, in aggregate, show the dangers of a serious downturn in tourist visitation, even without the occurrence of a release. With the critical role of tourism in the Nevada economy, even a minor shift to another location may result in a significant adverse impact on the county and state economies.

3.5 Effects of the Repository and Transportation on the Desert Tortoise

79 The Clark County Desert Conservation Plan is administered by the Environmental Division of the Department of Comprehensive Planning. The Environmental Division, the scientific community and other stakeholders are deeply concerned about any activity that may threaten the species' survival in the wild and its recoverability. Comments[1] submitted by the Environmental Division reflects the opinions regarding potential impacts on the desert tortoise of conservation and biological experts.

This group pointed out the insufficiency of the DEIS due to the lack of consideration of the well-being of the desert tortoise during various phases of repository construction, operation, monitoring and closure. Potential effects on the desert tortoise due to transportation by rail or highway were also discussed. A copy of this document is included to this report as Attachment A and is incorporated by reference to the present comments.

[1] Cannon Center for Survey Research. *Quality of Life in Las Vegas*. Report. City of Las Vegas, Nevada, 1999.

[2] Urban Environmental Research. Baseline Information and Community Perspective on Potential Repository Impacts on Clark County. Report. Clark County Nuclear Waste Division, December 1999.

[3] The White House. *Building Livable Communities: A Report from the Clinton-Gore Administration.* Washington, D.C. June 1999.

[4] University of Nevada, Las Vegas, 1988. Public Opinion in Nevada

4.0 YUCCA MOUNTAIN SITE-RELATED IMPACTS

Primary Reference: DEIS Chapters 3, 4, 5; Appendix A

Major Points of This Chapter:

- The disposal canister design evaluated in the DEIS is no longer being considered for license application. It is Clark County's contention that the difference in design is significant enough to invalidate the long-term (10,000 year) performance assessment given in the DEIS. The final EIS should be based on a design that is the same as the one DOE plans to use for license application.
- The spent fuel inventory and characteristics given in the DEIS do not accurately represent the spent fuel that the DOE will receive. The final EIS should include an up to date inventory and analysis of the spent fuel that is generated, with due consideration being given to the effect of higher burnup ratios.
- In view of the disposal of chemically toxic materials considered for the repository, RCRA regulations should apply.
- Saturated Zone data, away from the immediate vicinity of Yucca Mountain, is inadequate. Expert elicitation is not a substitute for data collection. The final EIS should include adequate data for the Saturated Zone, not only in the vicinity of Yucca Mountain, but out to the compliance boundary being considered by the EPA. If this boundary is not fixed by the time the final EIS is issued then the DOE should, as a minimum, have adequate saturated zone data to defend any assumptions that are made regarding the saturated zone.
- Attachment B of these comments provides documentation for each of the summary comments contained in this chapter.

4.1 Introduction

This section provides Clark County comments that focus primarily on DEIS analyses of environmental consequences of long-term repository performance. Clark County has provided commentary both on general issues and specific sections of the DEIS. A number of these issues have been previously addressed by Clark County in a contractor report, *Review of the Total System Performance Assessment in the U.S. Department of Energy Viability Assessment for the Yucca Mountain Site* (S. Cohen & Associates, March 28,1999). This report is incorporated by reference into Clark County's present DEIS comments. Specific findings will be cited that relate to the sufficiency of the DEIS. A copy of this report is included with these comments as Attachment B.

4.2 General Issues

4.2.1 Non-Compliance with Legal Standards

223... The Nuclear Waste Policy Act, As Amended, and codified in 42 U.S.C. 10101*ff.* defines high-level radioactive waste [HLW] as "requiring permanent isolation." "Barrier" is defined as "preventing release." 42 U.S.C. 10197 provides that while Yucca Mountain is being studied geologically, additional studies shall be performed in order to seek some combination of natural barriers and man-made barriers which, taken together as one "system," could assure Americans that HLW would be "isolated from the biosphere." Geologic findings by DOE in 1998 and 1999 demonstrated that no permanent isolation is possible under existing standards, and no

223 cont. engineered barrier is capable of preventing release of irradiated gases and water into the biosphere outside the site.[1]

Given these legal definitions and requirements and the geologic findings, *the DOE is legally obligated to declare the site unsuitable.* Either a different site, capable of permanent isolation, should be chosen, or some other definition of HLW should be created in Congress, by which this lethal burden would receive some other appropriate treatment.

4.2.2 Failure to Address Human Error in Repository Operation, Monitoring and Closure

80 Under NWPA provisions, any model or plan devised to illuminate, explain or predict any portion of site performance to be tested under actual conditions (or by extrapolation from well-corroborated knowledge) for seismic, hydrologic, and human intrusion scenarios. However, there is no requirement for investigating the potential for human error, the single largest historical contributory factor for accidents or incidents at DOE nuclear and weapons facilities and civilian nuclear power plants. This factor is completely ignored in the DEIS for any stage of repository construction, operation, monitoring and closure.

DOE must, therefore, initiate a full study of potential effects of human performance and error on repository operations, from construction to closure. Modeling simulations and probability estimates must be performed for every job assignment at each of these stages. These assignments may include loading and unloading of casks at points of departure and arrival, loading into the site, transporting the casks, operating monitoring equipment, administering quality assurance procedures, and so on. This is necessary to plausibly examine the probability and severity of consequences of human error that may lead to situations that may have environmental, economic, or public health and safety impacts.

4.3 Specific Comments Regarding Site-Related Impacts

4.3.1 Inventory and Characterization of Spent Fuel

81 DEIS Table A-2 indicates that a total of 4.5billion curies (Ci) were used for the proposed action. It is our understanding that the total number of Ci to be disposed of in the form of spent fuel range from approximately 11 billion Ci up to 19.3 billion Ci[2]. The documentation available in the DEIS is lacking in a clear and transparent rationale regarding the cause of this reduction from 11E9Ci's to 4.5 billion Ci and what scientific rationale was employed to validate this reduction.

82 Table A-5, *Typical Spent Nuclear Fuel Parameters*, and A-6, *Proposed Action Spent Nuclear Fuel Inventory*, represent the total inventory and age of spent fuel for the proposed action. However, in its analysis, DOE has neglected a change in industry practice that has significant impacts on the fuel that will be discharged in the future. This is the higher megawatt days per metric ton of heavy metal (MWd's per MTHM) criteria that is becoming more common in industry operation. The analysis given for the proposed action represents neither the thermal output nor the isotopic composition of the spent fuel that will be discharged from reactors in the future. The final EIS therefore needs to update the inventory and characterization of the spent fuel that is being considered for disposal.

83 The tables giving the radionuclide inventory (A-8 and A-9) both consider fuel that has had a decay time of ~25 years and has lower burnup than current industry practice. If younger spent fuel (See comments on Section 2.7) with a higher burn up rate is used, the number of Ci slated for disposal will have been underestimated.

4.3.2 Thermal Output

84... Much more significant to repository performance is the higher thermal output of the higher burnup and younger fuel. The DOE is now considering a repository design that includes drip shields and backfill. Neither of these options were fully analyzed in the DEIS. The effect of the addition of these two design options, is not only to decrease thermal conductivity near the disposal cask (by an amount that has not been considered in the DEIS), 84 cont. but also to change the temperature gradients in the vicinity of the cask. The effect of this has also not been analyzed in the DEIS.

4.3.3 Disposal Cask

85 The modifications contemplated by the DOE for the license application design include a significant change in materials for the disposal cask. Again, no attempt has been made in the DEIS to evaluate this effect, nor to look at possible manufacturing problems that could be encountered. These would not only affect the ultimate lifetime of the casks, but would also impact the rate and timing of juvenile failures.

4.4 Environmental Consequences of Long-Term Repository Performance

86 Clark County is concerned that the significant changes currently contemplated for the license application design are significant enough to totally invalidate the performance assessment calculations used in the DEIS. It is our contention that the final EIS must include an updated and valid analysis of long-term repository performance. The current TSPA in the DEIS, which is unchanged, in any significant manner, from that given in the Viability Assessment is outdated and no longer valid. The DEIS, if published in its current form, is no longer of any use as a decision document.

87 In discussing the effect of chemically toxic materials, DOE made the statement that organic materials (additions to the concrete) "could break down completely in response to exposure to high radiation fields for 100 years or more before closure." Does this mean that all of the repository will be open for a minimum of 100 years. In addition if there are high radiation fields, why is radiolysis ignored in the performance assessment calculations?

88 In Section 5.6, the DEIS presented consequences from chemically toxic materials. One of the elements considered in this analysis is chromium. The amount of chromium considered has been grossly underestimated since the design that the DOE is currently contemplating as the license application design uses stainless steel, instead of carbon steel as one of the barriers. In view of this, we feel DOE must consider whether RCRA regulations apply to the repository. If DOE feels that such regulations do not apply, they must provide rationale to support this position.

89 Section 5.2.3.4 discusses reductions in the concentration of radionuclides during their movement in the unsaturated and saturated zone. Statements are made to the effect that sorption would decrease the amount of radionuclides that are expected to reach the accessible environment. These statements are repeated in section I.3.1.1 for selected isotopes. No data are given to support this assertion and to show that certain radionuclides, will in fact sorb in the Yucca Mountain environment. Without actual data collected in the actual environment of the radionuclides, this assertion is unsubstantiated. The section regarding isotopes selected for long term performance should be completely rewritten and all statements regarding sorption should be backed up by data collected under conditions that are equivalent to the environment that the radionuclides will actually encounter if the repository at Yucca Mountain were constructed.

90 The scaling factor used for calculating the doses to the general population in Sections 5.4.1 to 5.4.3 is of concern to Clark County. It seems simplistic to dilute the radionuclide concentrations by the total amount of water usage in the Amargosa Valley. Does the Department of Energy have data that show that the flow field is so homogenous that this is valid. If, as the TSPA analysis uses, the system is dominated by stream tubes, how can this possibly be valid? What data will there be in the EIS to substantiate these assertions?

4.4.1 Conclusions About Long Term Repository Performance Based on the Total System Performance Assessment [TSPA]

91... The DOE's analysis of long term environmental consequences, as presented in the DEIS, suffers from the same shortcomings that were found in the performance assessment for the Viability Assessment [VA]. In that

91 cont. document, DOE stated that the TSPA-VA methodology and information base constitute a snapshot in an evolutionary process that leads potentially to a finding that Yucca Mountain is suitable as a disposal site. Such a finding of suitability would then lead to license application to NRC. However, further development of TSPA methodology and data will be needed for a TSPA with enough substance to support a license application.

The DEIS analysis of long-term environmental effects is based largely on TSPA findings. In view of this, we have summarized the principal findings of the Clark County contractor review of the TSPA in order to demonstrate the inadequacy of the DEIS results as an appropriate indicator of long-term consequences.

The following comments are taken directly from the Clark County contractor report, *Review of the Total System Performance Assessment in the U.S. Department of Energy Viability Assessment for the Yucca Mountain Site*, S. Cohen & Associates, March 28,1999).

Documentation and Computer Codes

92
- Some portions of the VA documentation did not meet DOE's objective to be clear and comprehensive in its description of TSPA-VA methodology, assumptions, and use of information. The VA provided only a limited description of the TSPA-VA computer codes and their use, and discussions of performance factors in the chapters of the Technical Basis Document were complex.

Modeling Assumptions and Performance Parameters

93
- DOE's selection of values for performance parameters was often based on limited data or recommendations from expert elicitations that were conducted in lieu of data. In some cases, such as waste package wall material corrosion rates (discussed in Attachment B), the base-case expected values used may not adequately represent the potential for radionuclide release and transport.
- DOE often selected features for TSPA-VA models that would produce high values for radionuclide release and transport. For example, it was assumed that the entire surface of the waste package is wetted when dripped on, that all seepage that contacts a package enters the package when the wall is penetrated, and that all of the waste form is exposed in a fuel rod with breached cladding.
- Some performance factors that could contribute to repository system performance, such as in-package dilution, were omitted from the TSPA-VA codes because the basis for characterizing performance parameter values was uncertain.
- A key feature of the models and computer codes used for the TSPA-VA analyses was uncoupling of thermal, hydrologic, chemical and mechanical phenomena that are known to be coupled. Coupled effects may be important to performance of a repository with the temperature and heat-load characteristics assumed for the TSPA-VA analyses, but the characteristics of coupling and their effects, and the effect of model uncoupling on the reliability of the TSPA-VA results, are uncertain.

Modeling Uncertainties and Data Sufficiency

94
- At this stage of the process toward evaluation of the suitability of the Yucca Mountain site for disposal, there were data deficiencies which limit confidence in some of the models used in the evaluations and in some of the parameter values used in the models.
- The results of the TSPA-VA evaluations also contain uncertainties associated with modeling of thermal hydrology, which is concerned with the effects of repository temperatures and heat loads on the characteristics of the rocks and hydrologic regime surrounding the emplacement drifts. At present, the data basis for this modeling is limited, and the validity of the models is uncertain. The TSPA-VA assumed that thermal hydrologic processes are short-lived and do not permanently alter the hydrologic regime.

Current information is insufficient to know if this is conservative or not. Thermal hydrology is discussed in Attachment B of these comments.

- The 10,000-year base-case dose-rate evaluation results, 0.04 mrem/yr, are principally dependent on assumptions concerning early failure of a waste package at 1,000 years and a climate change, which doubles the precipitation rate and causes an 80-meter rise in the water table, at 5,000 years. In the TSPA-VA models, assumptions concerning juvenile waste package failure and climate primarily affect the rate of seepage of water into the repository and the magnitude of the radionuclide source term.

- Use of conventional uncertainty characterization techniques showed that uncertainties in the base-case expected dose results span four to five orders of magnitude. This result is associated with the large number of parameters that have uncertainty ranges, either as a result of inherent, natural variability or as a result of current data uncertainties, including those resulting from lack of data.

- Overall, there is great "uncertainty in the uncertainty" associated with the TSPA-VA results. Uncertainty is present because of the many performance parameters that are genuinely variable and uncertain; because of uncertainty ranges assigned to parameters with limited data bases; and because of uncertainty ranges assigned to parameters that cannot have an experimental data basis, such as the number of juvenile package failures and future climate conditions. Uncertainty which cannot be explicitly characterized is also present in the TSPA-VA results because of uncertainty that the models used are appropriate and sufficient representations of actual conditions (e.g., uncertainties associated with uncoupling, in the models, of coupled phenomena). Experiments concerning the sensitivity of uncertainty to its various sources in TSPA evaluations might be done by running the computer codes with alternative models and parameter-value distributions.

Assumptions Regarding the Natural and Engineered Barrier Systems

95

- The natural barrier system was assumed to make no contribution to repository system base-case performance except for dilution of radionuclide concentrations by a factor of 10 during transit of the saturated zone. The burden for repository system performance was therefore placed on engineered features of the system, i.e., waste package wall corrosion resistance and cladding integrity.

- The TSPA-VA evaluations took credit for performance of cladding as an engineered barrier, but made assumptions that would tend to produce high values for release of radionuclides from the waste form. Such assumptions are concerned with the number of spent fuel rods with breached cladding, the exposed waste form area for each rod with breached cladding, and release of radionuclides with limited solubility, such as Np-237, from the waste form.

- For Tc-99 and I-129 (which are highly soluble, move with the ground water, and were found to be the only species to contribute to the 10,000-year dose rate), the assumption that natural system features contribute only limited dilution in the saturated zone to performance is realistic. The assumption is conservative for long-term dose rates, i.e., for 50,000 years and beyond, which are dominated by Np-237 and Pu-242, and for which some performance contributions from the natural system may be expected as a result of sorption on rock surfaces and the radionuclides' limited solubilities.

Waste Package

96

- DOE's selections of corrosion rate values for the waste-package Corrosion Allowance Material (A516 carbon steel) may not adequately represent the corrosion-rate potential because they do not account for the effects of drip velocity, and formation of salts and chlorides. Similarly, the corrosion rates for the Corrosion Resistant Material, Alloy 22, may not adequately account for adverse crevice-corrosion conditions. Corrosion rates are discussed in Attachment B.

97 ▪ The VA waste-package design is not an effective defense-in-depth design. Design options such as use of drip shields that were considered in the VA but not used in the TSPA-VA design have potential to significantly improve repository system performance.

98 ▪ As acknowledged by DOE, the TSPA-VA methodologies and information base are not adequate to produce results suitable for licensing reviews. They are, however, significant improvements over previous TSPA evaluations, and they are close to the status required for licensing reviews. Improvements needed for licensing would include revision or refinement of model details, revision of parameter values as a result of data additions, and improvement of the quality-assurance basis for models, computer codes, and data. The results of TSPA evaluations for licensing reviews will, as demonstrated by the TSPA-VA results, depend strongly on the repository design features (e.g., waste package design and thermal loading) selected for licensing.

REFERENCES

Review of the Total System Performance Assessment in the U.S. Department of Energy Viability Assessment for the Yucca Mountain Site, S. Cohen & Associates, March 28,1999).

[1] TRW Environmental Safety Systems Inc. *Total System Performance Assessment – Viability Assessment (TSPA-VA) Analysis.* Prepared for U.S. Department of Energy Yucca Mountain Site Characterization Office. November 1998

[2] Wymer, R.G. and A.C. Campbell. Chemistry in the Proposed Yucca Mountain Repository Near Field. January 2000.

5.0 TRANSPORTATION AND PUBLIC SAFETY IMPACTS

Primary Reference: DEIS Chapters 3, 6; Appendix J

Major Points of This Chapter:

- Assumptions and methodologies are inadequate or inappropriate for identification and analyses of impacts on the transportation system of Clark County.
- There were no estimates of the costs necessary to mitigate the impacts of emergency planning, response, evacuation and cleanup. This approach does not conform to best practice in the field of impact assessment.
- The DEIS did not establish a basis for mitigation negotiations since it did not assign specific roles and responsibilities for actions that cause impacts or ameliorate impacts.
- The DEIS used outdated databases, geographic data files, and inaccurate or misleading maps to support the conclusions of the transportation, health effects and public safety analyses.
- Section 5.3 contains very specific comments regarding DEIS description and analyses of transportation-related impacts in a number of areas, including public health and safety, transportation system, and socio-economic conditions. This section also addresses impacts on public safety programs and need for information for mitigation planning. Full exposition of these comments is contained in Attachment C of this document, as is a listing of sources consulted.
- Section 5.4 contains comments and NEPA Citations regarding specific DEIS statements about transportation and public safety.

5.1 Introduction

This section describes problems in the areas of transportation and public safety identified by Clark County in its review of the Yucca Mountain DEIS. There are substantive problems with the DEIS in both the areas of completeness and sufficiency. A careful review of the document reveals that despite the thoroughness with which some of the necessary information has been collected, there is very little analysis and interpretation of the information.

DOE's Yucca Mountain Program has been substantively criticized over a long period. These criticisms (notably in the comments to the 1986 Environmental Assessment and the Waste Management Programmatic EIS) led the DOE to indicate that the Yucca Mountain EIS would address issues raised in the past. These criticisms have not been addressed by the DEIS. New concerns have been raised by the DEIS' inadequacies.

This section describes Clark County's major concerns with the DEIS as they relate to transportation and public safety. In Section 5.2, we present and discuss a number of broad-based, or crosscutting, issues that are not directly related to any specific transportation impact. Section 5.2 contains a summary and a brief discussion of impact areas of primary concern to Clark County. Section 5.3 provides our comments regarding the completeness, sufficiency and NEPA compliance of specific statements in the DEIS regarding transportation.

Supporting information and documentation regarding the above commentary is contained in Attachment C of this document, *Clark County, Nevada Transportation Comments on U.S. Department of Energy's Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.* This attachment is incorporated by reference to the Clark County DEIS comments and contains extended discussions of transportation-related issues related to the DEIS and of importance to Clark County.

5.2 Crosscutting Issues Regarding Transportation Sections of the DEIS

5.2.1 Insufficient DEIS Policy, Strategies and Methodology

In preparing the DEIS, the DOE made certain assumptions and adopted procedures that had a strong influence in the approach and findings of the DEIS. These assumptions and procedures are described here as crosscutting issues. Although they do not specifically apply to each concern, they are identified here as problems that affect many portions of the DEIS, including the transportation sections.

99 The DOE adopted an unorthodox strategy in preparing the DEIS. Ignoring thirty years of best practice in the preparation of environmental impact statements, DOE chose to adopt the narrowest possible definition of an EIS and its purpose. In doing this, the DOE ensured that it found no impacts. The transportation analysis is typical of this approach. For example, the DEIS did not study traffic impacts that are normally considered in an EIS, choosing to base the estimation of transportation impacts solely on the risk of population and worker exposure to radiation. Congestion, lane widths, shoulder widths, peak hour traffic, roadbed conditions, and other conventional measures of traffic impacts were ignored. By narrowing the range of impacts studied, DOE made certain that the DEIS would identify no substantive transportation impacts.

100 Another example is found in the public health sections. By insisting that the DEIS is not an emergency planning document, the DOE avoided preparing any estimates of the costs necessary to mitigate the impacts of emergency planning, response, evacuation and cleanup. This approach is consistent with other DOE impact assessments (notably the Nevada Test Site EIS), but does not conform to best practice in the field of impact assessment. While this approach may have facilitated speedy preparation of the DEIS, it did not result in a thorough analysis of the impacts of the program and violates the letter and spirit of NEPA.

101 The purpose of an EIS is to establish a basis for mitigation negotiations. To achieve this goal, an EIS must assign specific roles and responsibilities for actions that cause impacts and for those that ameliorate impacts. This was not achieved in the DEIS. For example, the DEIS failed to provide this information regarding an implementing alternative for transportation routing. At a minimum, it should have provided a specific schedule for the construction of a route to Yucca Mountain, and defined specific agency responsibilities for constructing, maintaining and operating the route to Yucca Mountain. None of this has been accomplished, and in view of these omissions, Clark County and other affected jurisdictions do not have sufficient information necessary to effectively understand effects and negotiate mitigation.

102 There is an increased interest in risk assessment methodologies that better characterize and quantify uncertainty. The National Academy of Sciences has stated that, "Whenever possible, (upper bound potency estimates) should be supplemented with other descriptions of cancer potency that might more adequately reflect the uncertainty associated with the estimates." The National Research Council has made a similar call for a characterization of uncertainty. However, the estimates in the DEIS were presented as authoritative statements of risk, and the high degree of uncertainty in the estimates was left unstated. In order for the DEIS to have credibility with the public and policymakers, the DOE should have pursued an assessment strategy that addressed uncertainty rather than ignored it.

103 The quality of the report is flawed in fundamental ways. Sources cited by the report in Chapter 6 refer to reports that assumed the use of a Multi-Purpose Canister (MPC) system. The DOE has abandoned the MPC system as unworkable. Despite this, the DEIS uses references about the MPC design to support its conclusions even though they are not relevant for the proposed action described by the DEIS.

5.2.2 Use of Outdated and Inadequate Databases and Maps

104 In many cases, use of databases to support the conclusions of the report is also questionable. A major example of this is the reliance on 1990 Census data to estimate the health effects of transporting spent fuel. Detailed comments later in this report describe the seriousness of this underestimate.

105 Other databases are similarly flawed. In 1998, Clark County received geographic data files from DOE that were being used for the proposed implementing alternatives through Nevada to Yucca Mountain. Cartographers from Clark County's Geographic Information Systems Department found that the files provided by the DOE incorrectly located major transportation features (e.g., Interstate 15).

106 Maps presented in the DEIS are also fundamentally misleading. No national routes are depicted in the report. Many of the people who are most affected by the program, therefore, will not be aware of the impact based on
594 the report's contents. Maps in the DEIS fail to depict urban Clark County properly since they give the incorrect impression that a route using the beltway does not pass near urban Clark County. These maps also depict Las Vegas as a point, without illustrating the great expanse of urbanized Clark County. All of these concerns contribute to the impression that the report was prepared disregarding the most basic research standards and current information.

5.3 Transportation and Public Safety Concerns of Clark County

This section of the report summarizes Clark County's major concerns in the areas of transportation and public safety. While this is not a definitive list, it was developed after a careful review of the DEIS. Should more issues be raised during the comment period and beyond, Clark County will submit these immediately for DOE consideration. We have summarized the issues here and provided more detailed for each of these points in Attachment C.

Transportation Issues:

107
- DOE has proposed an unprecedented program of waste transportation in the DEIS. However, the record of previous transportation shipping campaigns is not encouraging. The DEIS should have provided a forecast of likely accidents.

108
- The DEIS is insufficient because it does not present any information about the operation of the transportation system. In other documents, DOE identified the following components of a transportation system: Design, Development, Certification, Testing, Acquisition, Operation of all necessary transportation equipment and services. By failing to describe these critical system components, DOE has failed to provide a credible EIS that assigns responsibilities and provides sufficient information to negotiate mitigation.

109
- The assessment of the risks of transporting spent fuel is not credible because the equipment proposed to transport and handle the waste does not exist. One of the reference materials provided in the DEIS indicate that no actual equipment exists for transporting, storing and handling the spent nuclear fuel. There are only "preliminary sketches" of the equipment.

110
- The DEIS analyzed no specific route through Nevada to the proposed Yucca Mountain facility. At a minimum, the DEIS should have described the process of selecting an implementing alternative. In 1995, the DOE reported that route evaluation criteria for the various transportation routes would be described in the DEIS. Nowhere does the document provide any description of how and why the DEIS will select the route evaluation criteria, how and when they will be applied and when the final route decision will be made. This is especially important in light of the DOE's decision to list the "Chalk-Mountain" route as non-preferred because of the objections of the Air Force. The DOE must explain why the Air Force was effectively granted veto authority over routes through Nevada.

111 ▪ The DEIS assumes a single route strategy for national transportation. There is no comparison of truck or rail alternatives, e.g., for the current regulations and for an alternative strategy.

112 ▪ The DEIS did not describe the volumes of waste that may travel on each highway or rail route.

113 ▪ The DEIS did not analyze the full range of modal alternatives. Specifically, it failed to analyze the risks of heavy haul transportation, despite the DOE proposal to use such transportation on congested freeways through densely urbanized areas of northern and western Las Vegas.

114 ▪ The DEIS should have indicated how human health risk will enter into decision-making. Based on the contents of the DEIS, risk assessment is not a worthy decision-making criterion. A comparison with the Generic EIS prepared by the Nuclear Regulatory Commission (NRC) for the licensing of nuclear power plants is instructive because it highlights the methodological inconsistencies in transportation risk assessment. The DEIS should explain how risk will be used and how it can be compared. The DEIS provides no basis for comparing routes within Nevada.

115 ▪ The DEIS failed to examine the likely interaction of the Yucca Mountain Program and other federal activities in Nevada. For example, while Clark County is in non-attainment for National Ambient Air Quality Standards (NAAQS), the DEIS did not mention the potential impact of the addition of heavy haul
116 or legal weight trucks into the transportation system. In addition, the DEIS did not analyze the effects that construction of the heavy haul infrastructure improvements or a rail line would have on the Regional Transportation Plan of Clark County.

117 ▪ The DEIS grossly understated the human health risk of transporting spent fuel by using 1990 Census data. The population has almost doubled since 1990 and will increase by a further large percentage should shipments of waste be initiated in 2010.

118 ▪ The DEIS failed to address the impacts on the Clark County transportation system that would be caused by program operations. For example, what would be the effect on traffic of a 300-foot long convoy carrying spent fuel, moving along a highly congested freeway at low speeds four times a day for 24 years? The DEIS is silent on the most likely and reasonable impacts of the transportation program.

119 ▪ The software used to analyze transportation risk in the DEIS was RADTRAN version 4.019. Extensive criticism of RADTRAN has been made in other venues. Although courts have allowed RADTRAN analysis of risk, the many shortcomings of this approach should have been examined in the DEIS. In particular, the DEIS should have provided the full RADTRAN outputs and interpreted their meaning. A portion of these outputs would have been the decontamination costs should an accident occur.

120 ▪ The DEIS examined only the problem of transporting 25 year old spent fuel. It is likely that younger, more radioactive fuel will be shipped to the Yucca Mountain facility. The DEIS should have examined this likelihood by bounding its analysis between 10 year and 25 year old spent fuel.

Public Safety

121 ▪ Congress has directed that localities affected by the Yucca Mountain Program be provided with funding to prepare emergency management assets for the program. The DEIS should have examined the institutional arrangements necessary to provide emergency response assistance to affected localities. The DEIS should have assigned specific roles and responsibilities for various federal agencies (such as the Federal Emergency Management Agency).

122... ▪ Of critical concern when examining the impacts of spent fuel transportation is the impact of a likely accident. The DEIS is insufficient because it failed to provide a clear description of the Maximum Reasonably Foreseeable Accident (MRFA). It did not analyze the costs to mitigate that accident or

122 cont. examine the cost to recover from that accident. It also failed to describe the preparedness activities, equipment, personnel, and facilities necessary to prevent, respond to or repair the effects of an accident.

123 There are serious impediments to local government response to transportation incidents. Mutual aid agreements among Nevada jurisdictions are inconsistent and do not cover many safety areas other than fire. While the DEIS indicated that emergency preparedness is an impact area, it did not address plans or strategies that are needed by local governments. In order to enhance public safety and provide detail for program planning, any mitigation plan must address the issues of:

- Interagency communication and institutional arrangements among DOE, the State of Nevada and local governments;
- Interagency communication and institutional arrangements among local governments and jurisdictions;
- Incident command;
- Response procedures;
- Evacuation planning and procedures in the unique resort setting of Clark County;
- Radiological monitoring;
- Emergency medical procedures;
- Use of communications systems;
- Information management technology;
- Mitigation strategies;
- Planning exercise design, and,
- Transportation safety.
- The DEIS does not identify either public safety needs nor does it identify the large amount of equipment needed by emergency medical services to respond to an incident.

124
- The DEIS failed to consider local and regional conditions with regard to communication among agencies in emergency situations. Any discussion of mitigation, support or compensation must address the development and maintenance of an adequate communication system for a transportation incident involving radioactive waste. The system must include such aspects as area of coverage, interagency arrangements, and backup systems.

125
- The DEIS failed to credibly address problems of security and terrorism. The only discussion of the issue was confined to the cursory refutation of arguments made by the State of Nevada. No discussion of eco-terrorism, civil disobedience, or the diversion of military equipment was included.

126
- Despite overwhelming evidence and fifteen years of commentary, the DEIS did not address the potential effects of human factors and institutional arrangements on transportation safety. The DOE has ignored the most likely cause of a catastrophic transportation accident.

5.4 Clark County Comments and NEPA Citations Regarding Specific DEIS Statements: Transportation and Public Safety

See Section 2.2.1.

127... **DEIS Statement (pg. 2-1)** - DOE has developed the information about the potential environmental impacts that could result from either the Proposed Action or the No-Action Alternative to inform the Secretary of Energy's determination whether to recommend Yucca Mountain as the site of this Nation's first monitored geologic repository for spent nuclear fuel and high-level radioactive waste.

127 cont. *Clark County Comment* - DOE believes that it has supplied sufficient data "regarding basic approaches" to transportation and that specific selection studies can be done later. The generalized information in the DEIS does not allow any community to adequately assess impacts nor design mitigation strategies. *NEPA Regulation: Sec. 1502.14 Alternatives including the proposed action; Sec. 1502.22 Incomplete or unavailable information*

128 **DEIS Statement (pg. 2-1)** - Although it is uncertain at this time when DOE would make any transportation-related decisions, DOE believes that the EIS provides the information necessary to make decisions regarding the basic approaches (for example, mostly rail or mostly truck shipments), as well as the choice among alternative transportation corridors. However, follow-on implementing decisions, such as the selection of a specific rail alignment within a corridor, or the specific location of an intermodal transfer station or the need to upgrade the associated heavy-haul routes, would require additional field surveys, state and local government consultations, environmental and engineering analyses, and National Environmental Policy Act reviews.

Clark County Comment - Unless DOE is proposing to consider construction of major new sections of the transportation routes, this document is inadequate because it does not provide detailed impacts but instead general, aggregated data. The existing rail and highway system, however, are fixed and DOE should have provided detailed data. Without such data about the alignment of the transportation routes, the impact analysis section is incomplete and meaningless. *NEPA Regulation: Sec. 1502.22 Incomplete or unavailable information.*

129 **DEIS Statement (pg. 2-9)** - The national transportation scenarios evaluated in this EIS encompass the transportation options or modes (legal-weight truck and rail) that are practical for DOE to use to ship spent nuclear fuel and high-level radioactive waste from the commercial and DOE sites to the Yucca Mountain site. DOE would use both legal-weight truck and rail transportation, and would determine the number of shipments by either mode as part of future transportation planning efforts. Therefore, the EIS evaluated two national transportation scenarios (mostly legal-weight and mostly rail) that cover the possible range of transportation impacts to human health and environment.

Clark County Comment - The DEIS used two scenarios (mostly rail and mostly truck) to analyze transportation impacts. These scenarios should have had a fully detailed impact analysis associated with each segment of the transportation corridor. *NEPA Regulation: Sec. 1502.14 Alternatives including the proposed action; Sec. 1502.22 Incomplete or unavailable information*

130 **DEIS Statement (pg. 2-38)** – The DEIS assumes that, at the time of shipment, the spent nuclear fuel and high-level radioactive waste would be in a form that met approved acceptance and disposal criteria for the repository.

Clark County Comment - The DEIS did not delineate how or who will be responsible for ensuring that the material to be disposed of is in approved form. *NEPA Regulation: Sec. 1502.1 Purpose; Sec. 1502.16 Environmental consequences*

131... **DEIS Statement (pg. 2-40) 2.1.3.2** - DOE has developed TRANSCOM, a satellite-based transportation tracking and communications system, to track current truck and rail shipments. Using the TRANSCOM system, DOE would monitor shipments of spent nuclear fuel and high-level radioactive waste to the repository at frequent intervals. This or a similar system could provide users (for example, DOE, the Nuclear Regulatory Commission, and state and tribal governments) with information about shipments to the repository and would enable communication between the vehicle operators and a central communication station.

Clark County Comment - Although the DEIS stated that TRANSCOM will monitor shipments of SNF and HLW," it also stated that "this or a similar system *could* provide users with information about shipments?" How can you measure the health and safety impacts and emergency management mitigation needs if it is not

131 cont. even clear how DOE plans to communicate with local entities? *NEPA Regulation: Sec. 1502.1 Purpose; Sec. 1502.14 Alternatives including the proposed action.*

132 **DEIS Statement (pg. 2-40) 2.1.3.2** - In heavily populated areas, armed escorts would be required for highway and rail shipments (10 CFR 73.37).

Clark County Comment - The DEIS stated that in "heavily populated" areas, armed escorts would be required. What is the definition of a "heavily populated" area? Who is going to pay for the armed escorts? Who pays for the additional Emergency Management equipment and staff required by the escort function? The DEIS should have delineated these costs as impacts and spelled out the responsible party. *NEPA Regulation: Sec. 1502.1 Purpose; Sec. 1502.14 Alternatives including the proposed action.*

133 **DEIS Statement (pg. 2-40) 2.1.3.2** - Section 180(c) of the Nuclear Waste Policy Act requires DOE to provide technical and financial assistance to states and tribes for training public safety officials in jurisdictions through which it plans to transport spent nuclear fuel and high-level waste.

Clark County Comment - The DEIS stated that DOE will train emergency management staff before the repository opens, but it does not detail who is considered EM staff. Further, no schedule is given. Local governments with limited resources will need an extended period of time and multiple training sessions in order to train staff while not disrupting existing services. The DEIS did not indicate whether DOE will provide multiple training opportunities over time for EM staff or who would for the staff time that is needed for additional training? Currently, local governments frequently have to absorb salary costs for staff in training. Is DOE going to pick up these costs or is this going to be another unfunded federal mandate on the State and local government? *NEPA Regulation: Sec. 1502.1 Purpose: Sec. 1502.22 Incomplete or unavailable information.*

134 **DEIS Statement (pg. 2-40) 2.1.3.2** - In the event of an accident involving a shipment of spent nuclear fuel or high-level radioactive waste, the transportation vehicle crew would notify local authorities and the central communications station monitoring the shipment. DOE would make resources available to local authorities as appropriate to mitigate such an incident.

Clark County Comment - The DEIS stated that "DOE would make resources available to local authorities as appropriate to mitigate" an incident. It did not explain how or when such assistance will be made available. Will local governments and the State of Nevada be burdened with the front-end costs of an incident and have to wait for reimbursement from DOE. If a significant incident occurred, it could be beyond the financial resources of a local entity. The DEIS should clearly state that the DOE will pay for any incident and pay for it up front. *NEPA Regulation: Sec. 1502.1 Purpose; Sec. 1502.22 Incomplete or unavailable information.*

135... **DEIS Statement (pg. 2-40) 2.1.3.2.1** - DOE would ship spent nuclear fuel and high-level radioactive waste from commercial and DOE sites in some combination of legal-weight truck, rail, heavy-haul truck, and possibly barge. This EIS considers two national transportation scenarios, which for simplicity are referred to as mostly legal-weight truck scenario and mostly rail scenario.

Clark County Comment - DOE identified two transportation scenarios (mostly legal-weight truck and mostly rail) without sufficient detail to analyze segment-by-segment impacts. Further, the DEIS stated that they may use barge, but there is no analysis of potential barge impacts. During the shipment of the steam generators from the Trojan Nuclear Power Plant to the Hanford Reservation via barge up the Columbia River, the barge carrying the generators had to wait for an extended period to allow another barge with a shipment of radioactive materials from foreign reactors to pass through the locks. The nation's waterways are a precious resource that in many instances experience heavy traffic. If DOE is considering allowing the use of barge traffic, then the DEIS should have a detailed analysis of potential impacts. In order to analyze impacts fully, DOE must look at the data at varying scales. For example, while the overall accident rate may be low in a

135 cont. specific corridor, in an urban area it may be much higher. The methodology used by DOE throughout the DEIS is designed to mask impacts – not to identify and mitigate them. *NEPA Regulation: Sec. 1502.1 Purpose; Sec. 1502.22 Incomplete or unavailable information.*

136 **DEIS Statement (pg. 2-43) 2.1.3.2.2** - A truck carrying a shipping cask of spent nuclear fuel or high-level radioactive waste would travel to the repository on highway routes selected in accordance with U.S. Department of Transportation (49 CFR 397.101), which require the use of preferred routes. These routes include the Interstate Highway System, including beltways and bypasses.

Clark County Comment - The DEIS stated that shipments would be made along the Interstate Highway system. Although this may be the "shortest path," it is also the path with the highest population density. Thus, more people will be exposed and more costly damage incurred from an incident along these routes. DOE should have considered an alternative that maximized the avoidance of dense urban areas. *NEPA Regulation: Sec. 1502.1 Purpose; Sec. 1502.14 Alternatives including the proposed action.*

137 **DEIS Statement (pg. 2-50) 2.1.3.3.2.2** - A small secure rail-yard off the main rail line would be established for switching operations. Railcars with spent nuclear fuel or high-level radioactive waste would have to be moved within 48 hours in accordance with U.S. Department of Transportation regulations (49 CFR 174.14).

Clark County Comment - The proposal to allow rail cars to sit at a rail yard for up to 48 hours invites terrorism, sabotage, vandalism and other health and safety risks. How does DOE plan to provide for protection of such rail cars? What does a "secure facility" mean? Armed guards? If so, paid for and reporting to whom? If DOE is planning to leave a rail car at the junction point until the following day so that they can link the end-journey transportation, they are creating, for example, the opportunity for terrorist intervention. Further, if
138 DOE is planning to piggyback rail shipments, then the cumulative impacts from this activity should be identified in the DEIS.

139 **DEIS Statement (pg. 2.51) 2.1.3.3.3.1** - To enable intermodal transfers and heavy-haul shipments to the repository, an intermodal transfer station *would be* built and operated in Nevada.

Clark County Comment - The DEIS is silent as to who is responsible for protecting shipments during the intermodal transfer. Further, the DEIS states that "it *could* build and operate an intermodal station." Is DOE committed to constructing and operating the intermodal transfer station, or is DOE going to contract this to the private sector? If so, who will have the liability from an incident at the intermodal station? Since most accidents with spent fuel occur with the transfer of waste, it is very important to know who will be responsible for this task; how it will be managed; and what role if any will be expected of local governments. Further, will local governments have the right to access such a facility to ensure compliance with regulatory standards? *NEPA Regulation: Sec. 1502.1 Purpose; Sec. 1502.14 Alternatives including the proposed action; Sec. 1502.16 Environmental consequences.*

140... **DEIS Statement (pg. 2-53) 2.1.3.3.3.1** - Road upgrades for candidate routes, if necessary, would involve four kinds of construction activities: (1) widening the shoulders and constructing turnouts and truck lanes, (2) upgrading intersections that are inadequate for heavy-haul truck traffic, (3) increasing the asphalt thickness (overlay) of some sections, and (4) upgrading engineered structures such as culverts and bridges.

Clark County Comment - The DEIS described needed road improvements in a general way but didn't identify who will pay for the construction and maintenance of such upgrades. Further, the DEIS stated that the turnout lanes would be built every 5-20 miles but didn't address specifically where these will be located. Nor did the DEIS examine whether the number of turnout lanes would be sufficient over the life of the repository. Since Clark County is experiencing such rapid growth, the design of transportation upgrades should allow for future enhancements funded by DOE as the population grows. It is inappropriate for DOE to expect that

140 cont. upgrades sufficient to meet today's traffic will be adequate over the life cycle of the repository. *NEPA Regulation: Sec. 1502.22 Incomplete or unavailable information*

141 **DEIS Statement (pg. 6-1) 6.1** - Although it is uncertain at this time when DOE would make any transportation-related decisions, DOE believes that the EIS provides the information necessary to make decisions regarding basic approaches (for example, mostly rail or mostly truck shipments), as well as the choice among alternative transportation corridors.

Clark County Comment - The DEIS argued that without specific transportation routes being identified, DOE can still choose "basic approaches" with sufficient information to assess the level of impact. We believe that, since accident rates vary along segments, DOE cannot determine impacts without identifying specific routes. It is also unclear whether DOE will conduct additional NEPA review for every transport segment when the route and mode mix is finally completed. DOE should explicitly address this point in the DEIS. Further, detailed segment-by-segment assessments of the selected transportation corridors should be made in compliance with the intent of NEPA. These analyses should determine potential impacts on quality of life, public safety, and environmental justice at varying scales. *NEPA Regulation: Sec. 1502.22 Incomplete or unavailable information.*

142 **DEIS Statement (pg. 6-6) 6.1** - Over the 24 years of the Proposed Action, an estimated six and two latent cancer fatalities, respectively, could occur in involved worker populations from radiation exposure for the mostly legal-weight and mostly rail scenarios. The probability of a latent cancer fatality to the maximally exposed involved worker would be about 0.005 for both scenarios. No worker fatalities from industrial accidents would be expected. No or very small impacts to workers or members of the public would be expected from postulated loading accidents.

Clark County Comment - The DEIS estimated six (mostly legal weight truck scenario) or two (mostly rail scenario) deaths over 24 years to workers from radiation exposure. It also states that there will be no "worker fatalities from an industrial accident." Yet, most accidents to date at nuclear power plants have actually involved exactly this type of incident. On what grounds does DOE make this assertion? *NEPA Regulation: Sec. 1502.22 Incomplete or unavailable information.*

143 **DEIS Statement (pg. 6-6) 6.1** - Over the 24 years of the Proposed Action, an estimated 18 latent cancer fatalities could occur in the general population along transportation routes from radiation exposure under the mostly legal-weight truck scenario and an estimated two latent cancer fatalities could occur under the mostly rail scenario. For involved workers, an estimated five latent cancer fatalities could occur in the involved worker population from radiation exposure for the mostly legal-weight truck scenario, and an estimated one latent cancer fatality could occur for the mostly rail scenario.

Clark County Comment - The DEIS estimated 18 latent cancer fatalities among the general public and five among transport workers over 24 years under the incident free scenario. Without a segment-by-segment of the selected transportation routes, it is impossible to assess whether these deaths will fall inequitably on certain sectors of the population. *NEPA Regulation: Sec. 1502.22 Incomplete or unavailable information.*

144 **DEIS Statement (pg. 6-8) 6.1** - Nationwide, during the 24 years of the Proposed Action transportation activities, about four fatalities could result from traffic accidents under the mostly legal-weight truck scenario. For the same time period, about four fatalities could also result from traffic accidents under the mostly rail scenario. These fatalities would all be related to physical injuries associated with traffic accidents, not radiological impacts.

Clark County Comment - Under the transportation accident scenario for either rail or truck, four fatalities are forecast over 24 years. Without route identification, it is impossible to ascertain whether low-income or minority communities may be unduly burdened at the local scale. *NEPA Regulation: Sec. 1502.22*

6.0 PUBLIC COMMENTS AND PUBLIC OPINION

Primary Reference: DEIS Chapters 1, *3*

Major Points of This Chapter:

- Clark County staff met with 19 Town Advisory Boards/ Citizens' Advisory Councils, representatives from local jurisdictions and other groups to exchange information and receive comments on the Yucca Mountain DEIS. It is clear from the comments recorded that not only county officials, but also citizens, are very concerned about the negative impacts that the Yucca Mountain Program may have on Southern Nevada.
- Specific issues raised in the comments include the need to acknowledge and assess the impacts on Native Americans, and more fully consider public safety, environmental impacts, environmental justice, funding to local governments, effects on land use, perception-based impacts of DOE activities, performance assessment, interaction of the repository on local and regional plans, public participation, regulatory standards, schedule & licensing, socio-economic impacts, storage, and transportation issues.
- *According to comments by Clark County governmental representatives, residents, and other stakeholders made at public meetings and by other means, DOE has:*
  - Ignored cumulative impacts from past and continuing NTS activities.
  - Ignored negative economic impacts that could potentially devastate the economy of Southern Nevada.
  - Ignored existing and planned land uses in the proposed transportation campaign.
  - Used population data that greatly underestimates the impacts on Clark County.
  - Not done enough to let the general population know about something so significant that could have such far-reaching impacts.
  - Underestimated the real and potential impacts of the proposed transportation campaign.
- DOE is not trustworthy – based on past history and currently not listening to citizen concerns.
- We are helpless against what seems to be a done deal, so it is futile to get involved.
- The waste should be stored where it is because new technology can be developed to take better care of it.
- Radiological impacts are greatly underestimated.
- There are a number of problems with bringing all the waste together at Yucca Mountain that are being ignored.
- Other storage options should be considered.
- The impact to future generations and other unusual impacts are not adequately addressed.
- Attachment D includes a copy of the Clark County Community Involvement Tracking System that provides categorized and dated commentary by government officials, members of interest groups, and members of the general public.
- Attachment E includes letters of comment by Greater Las Vegas Association of Realtors, the Southern Nevada Homebuilders Association, the Clark County Comprehensive Plan Steering Committee, the Laughlin Town Advisory Board, and the Winchester Town Advisory Board.

6.1 History of Public and Agency Comments Regarding Yucca Mountain

145... Since 1988, Clark County has recorded comments pertaining to the Yucca Mountain Project and its potential impacts on Clark County. From the very beginning, great concern about the potential repository has been expressed by Clark County officials, staff and others. Specific issues raised in the comments include the need to acknowledge and assess the impacts on Native Americans, issues to be addressed in the EIS, emergency response considerations, environmental impacts, environmental justice, funding, land use, perception-based impacts of DOE activities, performance assessment, planning considerations, public participation, regulatory standards, schedule & licensing, socio-economic impacts, storage, and transportation issues.

It is clear from the comments recorded that not only county officials and NWD staff, but also citizens, are very concerned about the negative impacts that the Yucca Mountain Program could have on Southern Nevada.
146 Comments relating to cultural and historical resources, for example, urge DOE to be very serious about their handling of Native American issues. The DEIS however, makes little mention of Native American issues other
147 than to acknowledge that there are Native American issues that need to be addressed. Requests for a review of the effects of past DOE (and predecessor) activities in Southern Nevada have not been addressed in the DEIS, however. Others asked that DOE address inequalities and the "political" aspects of the issue but these were similarly not addressed in the DEIS. And the comments go on.

Attachment D provides information that is stored in the Nuclear Waste Division's *Community Involvement System [CITS].* This system is designed to help staff record and categorize public meeting comments. Comments may be categorized by name, date, subject, agency or group representation [if any], and geographic location. Early comments did not have dates associated with them, but beginning with 1992, the dates of the comments are noted.

6.2 Summary of Public Comments During Present DEIS Comment Period, August 1999-February 2000

This section provides a summary of comments gathered at meetings held in Clark County during the Yucca Mountain DEIS comment period. These included city council meetings, Town Advisory Board / Citizens Advisory Council meetings, and meetings with professional organizations, businessmen and women, and interested citizens groups. At these meetings, Clark County Nuclear Waste Division staff made presentations, answered questions and noted comments from the general public and officials in attendance. Presentations were made at more than 20 meetings covering geographical areas, rural and urban of Clark County.

Nuclear Waste Division staff participated in public, committee or staff meetings with representatives of the cities of Boulder City, Henderson, Las Vegas, Mesquite, and North Las Vegas. Staff also participated in Town Advisory Board or Citizens Advisory Council meetings in the unincorporated areas of Bunkerville, Enterprise, Goodsprings, Indian Springs, Laughlin, Lone Mountain, Mt. Charleston, Mountain Springs, Moapa, Moapa Valley, Paradise, Red Rock, Searchlight, Spring Valley, Sunrise Manor, Whitney and Winchester. Presentations were also made to the Clark County Local Emergency Response Committee, the Clark County Comprehensive Plan Steering Committee, the Laughlin Chamber of Commerce, the Greater Las Vegas Association of Realtors, the Howard Hughes Corporation, and the Southeast Coalition of Concerned Citizens.

Some of these individuals, groups or jurisdictions have submitted comments directly to DOE, while comments by the Clark County Comprehensive Plan Steering Committee and the Greater Las Vegas Association of Realtors are attached to this document.

145 cont. The following section lists comments noted by NWD staff at the meetings mentioned. A total of more than 650 people attended the meetings. Comments show that, with two exceptions, citizens are deeply concerned that DOE is not really listening to the people of Nevada and the country. There was great concern about the transportation of the waste to Yucca Mountain. Many people commented that they were surprised that citizens

147 cont. across the country weren't up in arms that the waste could come through their communities.

148 Many people expressed a very high level of mistrust for DOE, because of their past dealings with the people of Nevada. Examples were given of family members who played in the ash from the fallout of above-ground tests because they were told there was nothing to be concerned about, "just wash your vegetables." These family members it was noted by the public later died from cancer. Other meeting participants have family and close friends who lived "down wind" from the Nevada Test Site (NTS) and have suffered the ravages of cancer. Some survived and others died. The concern was expressed that Nevada has already suffered and continues to suffer the impacts of the nuclear testing that went on at the NTS and that Yucca Mountain could add in *unknown* ways to the impacts that they are already suffering.

6.2.1 Notes of Public Meetings Attended by NWD Staff Throughout Clark County

This section includes a summary, by category, of the comments that were noted by Nuclear Waste Division staff in attendance at the meeting of town advisory boards, citizens advisory councils, city councils and other interested groups. The comments are concise summaries of statements made. There are redundancies among the comments, but since they were gathered at a number of locations around the county, we have included all of them for consideration.

GENERAL (provide context for DEIS comments)

- City Attorney will continue to put together comments on the draft EIS for the City.
- Encouraged citizens to get involved in commenting or attending the public hearing.
- Encouraged individual residents to make comments on their own.
- Protests helped stop Ward Valley in California, we should be involved with Yucca Mountain.
- Agreement with TAB concerns and questions.
- Encouraged citizens in attendance to get involved and comment on this important issue pointing out that the waste and spent fuel could be transported through the center of Enterprise along I-15 and the beltway.
- Several asked for additional information packets to take to friends and family.
- Encouraged Clark County or State to provide forms at the public hearing for people to fill out and submit their comments.
- Voted to send a letter to DOE in opposition of Yucca Mountain - voicing the concerns of the TAB.
- Encouraged citizens to get involved and comment on this important issue.
- Encouraged people to get involved.
- Concerned about the number of people who seem disinterested, that they really don't know how adversely it could impact them.
- TAB members said they would make contacts to try and get people involved.
- Hope that citizens of the community will get involved.
- Urged citizens to be involved and let DOE know that the citizens of the community are concerned.

HELPLESSNESS

149
- There was a feeling of helplessness in some people.
- Many wanted to do something but felt overwhelmed or that it was futile.
- Others commented on feeling overwhelmed and that their effort would be futile.
- Feeling that the larger cities, county and state would lead the fight to keep it out of Nevada and that there wasn't much they could do to make a difference.
- Feelings of helplessness about stopping waste coming on I-15 through Mesquite - can't pick up and leave jobs and homes.
- Interest and concern, but a sense of helplessness against an agency that they perceive as not trustworthy.

CUMULATIVE IMPACTS

150 ▪ Concern that DOE is not taking into account that Nevada is already impacted by the Low-Level Waste shipments that are going to NTS and the continuing effects of the nuclear tests that were performed there.
▪ Concern that DOE is not considering all the impacts Southern Nevada has already received from operations at the NTS.

ECONOMIC IMPACTS

151 ▪ Concern that their property values will be deeply impacted because of waste being transported near their homes.
152 ▪ Who will pay for the maintenance and/or upgrades to roads, bridges, etc. that will be impacted by the transportation?
153 ▪ Interested and hopeful that DOE would consider the impacts to Nevada that they had not considered: economic impacts to gaming/tourism, trucking impacts that were not really considered - "there will be accidents," stigma to products, etc.
154 ▪ What about negative impacts to small businesses near the transportation routes?
▪ The gaming industry should take some lead in this and realize how dramatically they could be impacted.
155 ▪ One person felt that it was a good thing because it would bring high paying trucking jobs to the community. He didn't think there was a radiological risk and cited his knowledge of a mine in Canada that was so radioactive that it made the stuff that would be coming to Yucca Mountain looks like spit - the stuff in Canada was magnitudes of times greater in radioactivity. He said that if we didn't want the waste shipped here, Canada would take it there and reap the economic benefits.
156 ▪ Concerns that DOE is not really looking at the impacts to the economy.
157 ▪ One person felt that there weren't great risks from the waste coming through and that it would add jobs to the economy. Other citizens responded that the jobs would be technical or high risk and not really be available to the people living here.
158 ▪ Don't believe that DOE is really looking at the potential impacts to the citizens and economy.
159 ▪ Wondered if gaming is involved because their weight behind opposing Yucca Mountain would have greater influence.
160 ▪ Concerned that waste coming through the area could have a devastating impact on the economy.
161 ▪ Concerned that the poor will be greatly impacted.
162 ▪ Investments have been made and continue in developing what is considered a premier property (Summerlin). Nuclear waste being transported through the middle of the property could have devastating economic impacts.

LAND USE IMPACTS

163 ▪ DOE ignored the land use plans but we have to live with them for a long time.
164 ▪ It seems obvious that DOE did not look at the site plan for Summerlin or the Las Vegas Valley and all the residential and commercial uses planned along the western beltway.
165 ▪ It is unbelievable that DOE is even considering transportation of the waste along the beltways through populated Las Vegas Valley.

MITIGATION

166 ▪ Concerns about not getting compensation (money) for accepting the waste.
167 ▪ Others felt that now is the time to go after DOE for mitigation funds.
168 ▪ Asked about mitigation steps that were being taken.

NEW TECHNOLOGY

169 ▪ Leave the waste where it is generated until something better can be done.

170 ▪ Isn't it safer to store it on site, above ground, for a while until new technology can help us handle it in a better way than burying it?

171 ▪ Want the waste kept out of Nevada, leave it where it is until some better technology can be produced.

172 ▪ Hopeful that DOE would really look at how adversely this could impact the whole country and look at doing something else.

▪ Hope that perhaps DOE would listen to the people and look at other ways of taking care of the waste.

▪ Wondered why nothing else is being considered by DOE or Congress, since so many new technologies are being developed all of the time.

POPULATION DATA

173 ▪ 1990 Census figures are being used and don't reflect the growing population in the north portion of the valley.

174 ▪ Can the EIS be thrown out since the data is so out of date?

175 ▪ Several wondered about the audacity of DOE in proposing to take the waste through such a heavily populated area that is continuing to grow at such a high rate.

176 ▪ Concerned that DOE is not really considering the impacts to people along potential routes, especially in Southern Nevada where population has grown so dramatically.

PUBLIC INVOLVEMENT

177 ▪ Concern that more citizens weren't involved.

▪ Those in attendance wondered why they hadn't heard more about this before from DOE.

▪ Encouraged the Clark County Nuclear Waste Division really spread the word and try and get people involved because DOE won't do it.

▪ Concerns about general public not really being aware of the impacts because DOE has not really made an effort to get the word out.

▪ DOE should have made a much greater effort to let people know about something so long lasting and potentially harmful as this.

▪ Concerned that a lot of people who would be adversely affected, don't even know about it because of inadequate public outreach by DOE.

RADIOLOGICAL IMPACTS

178 ▪ Great concern that the health impacts are not really reported. There are lots of things besides deaths from radiological exposure (from a member of the TAB who is a doctor).

▪ Concerns that radiological impact could be far greater than what is being reported.

SITE ISSUES

179 ▪ Concerns over effects of the radiation in the area where it would be stored because of problems they observed when they lived in the Tri-Cities area near Hanford. Effects on animals and plants, etc.

180 ▪ The original analysis contained several critical, technical flaws that need to be addressed.

181 ▪ Concerns about all the waste together in one place creating a sabotage or safety issue (critical mass).

182 ▪ Earthquake action in the area (recent quake not too far from Yucca Mountain) raises great concerns.

183 ▪ Concerned that with the amount of money that has been spent on studying Yucca Mountain it will become a repository even if though there are problems with water flowing through the mountain, earthquakes, and volcanic activity.

Storage

184 ▪ Take care of the waste where it was created, at the generation sites.

185 ▪ One man, educated in this area, feels that salt mine storage or uranium mine storage would be better. He also indicated that he felt that it should be stored regionally and not transported across the country.

Transportation / Routes / Casks

186 ▪ Great concern that the potential route goes along the western beltway - there is a new high school that is adjacent to the beltway alignment (beltway has not been constructed in this area yet).

187 ▪ Concern that there could be accidents at the interchange of the beltway and Highway 95. How would heavy-haul trucks make the turns at the interchange?

188 ▪ Concern over transportation no being more specific: no licensed casks, commercial carriers not adequately trained, not knowing route, etc.

189 ▪ Asked about the possibility of legal-weight trucks being diverted off of I-15 through their community - that would be a very serious mistake (Logandale, Overton).

190 ▪ Concerns about driving into Las Vegas and traveling on the Interstate with the trucks - not being aware or having to delay commutes so as not to travel along side or near the trucks.

191 ▪ Concerned about the safety of the casks and trucks.

192 ▪ Concerned about the human error factor of truck drivers.

193 ▪ Asked if the cask was licensed.

194 ▪ Wondered if the City Council could legally create a "nuclear free zone."

195 ▪ Concern that Craig Road could be used as a route.

196 ▪ Concerns about the potential of it going through Mesquite because can't trust the DOE won't do it.

197 ▪ Transportation is a big issue, 'it's a craps game by putting it on a truck' - transportation is a very dangerous environment.

198 ▪ Focus on national transportation (not in Everybody's backyard) to keep congressional delegation united in fighting it across the country.

199 ▪ Hopeful that DOE would consider trucking impacts that were not really considered - "there will be accidents."

200 ▪ Members of the TAB asked questions about the potential impacts from transportation through Enterprise.

201 ▪ Questions were asked about the number of potential shipments.

202 ▪ City Council members expressed concern about the possibility of waste coming through Boulder City either along US Highway 93 or across Boulder Dam.

203 ▪ One man, educated in this area, commented that he is very concerned about the transportation of nuclear waste around the country.

204 ▪ Hopeful that Boulder Dam would not be used as a transportation route.

205 ▪ Concern about the waste potentially coming through Spring Valley along the western beltway.

206 ▪ Concerns about the radiological impacts of transporting it through the community.

207 ▪ Don't want it transported along I-15, the doorstep to their community.

208 ▪ Concerned about the transportation along I-15 through Mesquite where most of the schools are within ½ mile of the Interstate. The children of this community go to those schools and could be adversely impacted.

209 ▪ Concerned about commuting along I-15 to Las Vegas or St. George and either traveling with the trucks carrying the waste or having to delay trips to avoid traveling near the trucks.

210 ▪ Extreme concern about the waste traveling through the Virgin River Gorge where there the road is windy and narrow and accidents occur frequently and tie up traffic.

211 ▪ Wanted to know how they would lift a cask out to the gorge if one fell into it there or at one of the bridge crossings not right in the gorge.

212
- Concern about the impacts of trucks hauling the waste on people's health and safety.

213
- Concern that DOE is not really looking at the impacts along the transportation routes in the smaller communities.

214
- Concern that DOE did not rule out the use of Highway 160 that goes right through the middle of their community.

215
- Concern about the demand on emergency response if Highway 160 were used because they are a volunteer unit and do not have the training or equipment to respond.

216
- Concerned about the impact that the transportation of the waste could have on Southern Nevada.

217
- Concerned about potential traffic accidents and impacts even if there is not release of radioactive material.

TRUST

218...
- Some seemed to think it was a done deal.
- Concern over Yucca Mountain being the only site studied - seems like there is no way to stop it.
- Disbelief that there is no other sites being considered.

219...
- General feeling of not trusting DOE because of past record of being lied to about hazards from testing in Nevada - people dead in community.

218 cont.
- Great concern, and even anger, on what they perceived as having Yucca Mountain shoved down their throats.
- Concern that no other place is being studied and that it is a "done deal."
- How can DOE force this on the people of Nevada?
- Citizens were generally concerned and wanted to know if their efforts would fall on deaf ears.
- It seems predetermined that the waste will come to Yucca Mountain, public comments seem perfunctory.
- Indicated that it was depressing to think that the waste could be transported to Yucca Mountain because of feeling like it was a done deal.

220...
- Asked if comments would even be recorded at the public hearing - "they [DOE] don't really listen."

219 cont.
- Concerns that DOE has not been truthful before and that it could have far greater impacts then they are saying.

218 cont.
- Concerned that DOE does not really listen to what is being said, that they will go ahead even if it really isn't in the best interest of the public because so much money has been put into the project so far.

219 cont.
- Concern about DOE not really disclosing impacts.
- General mistrust for DOE because of past record associated with NTS and leaking shipments across Boulder Dam.
- Don't trust DOE and their analysis of what could happen.
- DOE has lied in the past and they could do it again.

218 cont.
- Do not feel that DOE is trustworthy in what they are reporting as the potential impacts.
- Concerned that comments will fall on deaf ears.

219 cont.
- Concerned that DOE was not really looking at the negative impacts.
- Don't trust DOE - their analysis or that they will do the right thing.

218 cont.
- Concerned that because of the money that has been spent and other reasons, it will happen "no matter what." [4 comments]

220 cont.
- Doubt if they would really be listened to by DOE.

219 cont.
- Do not trust DOE or Congress to do the right thing, only what is easiest at the moment.

UNUSUAL IMPACTS

221
- Indicated that if a spill went into the Virgin River it could impact the "endangered" fish in the river.

222
- Many of the people expressed genuine concern about the potential impacts to them and their descendants.

6.3 Other Comments

Attachment E of this document contains letters of comment from the Greater Las Vegas Association of Realtors, the Southern Nevada Home Builders Association, the Clark County Comprehensive Plan Steering Committee and the Laughlin and Winchester Town Advisory Boards. Members of each of these groups have specific concerns regarding planning issues, and impacts on land use, property values, economic conditions, and health, safety and quality of life impacts.

ATTACHMENTS

A. Clark County, Nevada, Department of Comprehensive Planning, Environmental Division. *Comments on the Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.* February 4, 2000.

B. S. Cohen & Associates. *Review of the Total System Performance Assessment in the U.S. Department of Energy Viability Assessment for the Yucca Mountain Site.* Report for the Clark County Nuclear Waste Division, March 28,1999.

C. Clark County, Nevada, Department of Comprehensive Planning, Nuclear Waste Division. *Clark County Transportation Comments on U.S. Department of Energy's Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.* February 2000

D. Clark County, Nevada, Department of Comprehensive Planning, Nuclear Waste Division. *Community Involvement Tracking System [CITS].* Public and Agency Comments up to September 1999.

E. Other Comments:

Letters from:

Greater Las Vegas Association of Realtors
Southern Nevada Home Builders Association
Clark County Comprehensive Plan Steering Committee
Laughlin Town Advisory Board
Winchester Town Advisory Board

ATTACHMENT A

CLARK COUNTY, NEVADA, DEPARTMENT OF COMPREHESIVE PLANNING, ENVIRONMENTAL DIVISION. COMMENTS ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

EIS001888

Department of Comprehensive Planning

Environmental Division

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John L. Schlegel, Director • Christine Robinson, Planning Manager

February 4, 2000

Ms. Wendy R. Dixon, EIS Project Manager
Yucca Mountain Site Characterization Office
Office of Civilian Radioactive Waste Management
U.S. Department of Energy
P. O. Box 30307, M/S 010
North Las Vegas, Nevada 89036-0307

Dear Ms. Dixon:

Please find enclosed comments on the Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada. These comments were provided by a subcommittee of the public Implementation and Monitoring Committee of the Clark County Desert Conservation Long-Term Plan for the Desert Tortoise and represents the opinions and analyses of conservation and biological experts on the desert tortoise (Gopherus agassizii) for which the County holds a Section 10(a) 1(b) Endangered Species Act permit for the take of the desert tortoise.

These opinions were based on a review of the Draft EIS by this subcommittee of scientists who form part of the Clark County Board of County Commission-appointed public Implementation and Monitoring Committee where they serve as stakeholder representatives for the scientific community concerned with the recovery of the desert tortoise population in the Eastern Mohave range. Several of these individuals serve on the federally-appointed Recovery Team for the Eastern Mohave population of the desert tortoise, and hence, are nationally recognized experts on this species.

We are happy to provide these comments to you for your consideration. The economic prosperity and environmental integrity of Clark County are directly linked to our continuing to meet the conditions of the Incidental Take Permit issued by the United States Fish and Wildlife Service and we are deeply concerned with any and all activities which might threaten the health and well-being of significant desert tortoise populations throughout the Eastern Mohave range as well as their survivability in the wild. While the conditions of our permit are directly related to our plan for mitigating the loss of desert tortoise populations in Clark County, the federal Recovery Plan for the species expands across the entirety of the species' Eastern Mohave range. Therefore, we are greatly concerned with the affects of activities both within Clark County and throughout the northern portions of the range of the desert tortoise which may affect the species' recoverability over the next thirty years which is the duration of the permit we currently hold.

Please feel free to contact me if I can provide further information.

Sincerely,

Cynthia J. Truelove, Ph.D.
Desert Conservation Plan Administrator

CJT:rmt
Enclosure

Comments on the Draft –
Environmental Impact Statement for a Geologic
Repository for the Disposal of Spent Nuclear Fuel
and High-Level Radioactive Waste at
Yucca Mountain, Nye County, Nevada,
Volume I - Impact Analyses, Chapter 1 - 15.

We find that the Draft - EIS does not sufficiently address the following specific issues:

1. The discussion of Impacts to Biological Resources and Soils from Performance Confirmation Section 4.1.4.1) is inadequate because it fails to properly consider and address the regional and rangewide implications of the loss of unique desert tortoise (Gopherus agassizii) populations and the genetic potential of these populations at the northern extremes of this species* range. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in traffic on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range due to this activity. It is inadequate because it fails to adequately consider and address the regional and rangewide implications of increases in raven populations and their increased levels of predation on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range due to this activity. This issue is of concern to Clark County because it is engaged in supporting significant conservation actions in areas adjacent to and in the regional vicinity of the Repository that may be indirectly impacted.

2. The discussion of Impacts to Biological Resources from Construction, Operation and Monitoring and Closure (Section 4.1.4.2) is inadequate because it fails to properly consider and address the regional and rangewide implications of the loss of unique desert tortoise (Gopherus agassizii) populations and the genetic potential of these populations at the northern extremes of this species* range. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in traffic on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range due to this activity. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in raven populations and their increased levels of predation on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range due to this activity. This issue is of concern to Clark County because it is engaged in supporting significant conservation actions in areas adjacent to and in the regional vicinity of the Repository that may be indirectly impacted.

3. The discussion of Impacts to Biological Resources from Retrieval (Section 4.2.1.2.4.1) is inadequate because it fails to properly consider and address the regional and rangewide implications of the loss of unique desert tortoise (Gopherus agassizii) populations and the genetic potential of these populations

at the northern extremes of this species* range. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in traffic on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range due to this activity. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in raven populations and their increased levels of predation on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range due to this activity. This issue is of concern to Clark County because it is engaged in supporting significant conservation actions in areas adjacent to and in the regional vicinity of the Repository that may be indirectly impacted.

4. The discussion of Consequences to Biological Resources and Soils (Section 4.2.1.2.4.1) is inadequate because it fails to properly consider and address the regional and rangewide implications of the loss of unique desert tortoise (Gopherus agassizii) populations and the genetic potential of these populations at the northern extremes of this species* range. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in traffic on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range due to this activity. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in raven populations and their increased levels of predation on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range due to this activity. It is inadequate because it incorrectly asserts that "Desert tortoises are rare or absent on or around playas..". Recent work by Dave McCullough (pers. com.) in the vicinity of Ivanpah Dry Lake has found that desert tortoises are much more common in Atriplex sp. Communities surrounding playas than was previously believed. Therefore, discharge of radioactive and toxic effluent would pose a more significant threat than is currently being considered. This issue is of concern to Clark County because it is engaged in supporting significant conservation actions in areas adjacent to and in the regional vicinity of the Repository that may be indirectly impacted.

5. The discussion of Environmental Impacts of Transportation to Biological Resources and Soils (Section 6.1.2.4) relating to the construction of a branch rail line is inadequate because it fails to properly consider and address the regional and rangewide implications of the loss of unique desert tortoise (Gopherus agassizii) populations and the genetic potential of these populations at the northern extremes of this species* range. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in traffic on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range due to this activity. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in raven populations and their increased levels of predation on unique desert tortoise (Gopherus agassizii) populations at the

northern extremes of this species* range due to this activity. This issue is of concern to Clark County because it is engaged in supporting significant conservation actions in areas adjacent to and in the regional vicinity of the Repository that may be indirectly impacted.

The discussion of impacts of construction of a branch rail line is inadequate because it fails to properly consider and address the regional and rangewide implications of loss of individuals and that loss*s impact on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range due to this activity.

The discussion of the Jean rail corridor is inadequate because it fails to consider that this corridor would pass through or near the Clark County Desert Tortoise Large-Scale Translocation Study Site (LSTS) west of Jean. Clark County has invested significant resources in establishing this site and funding studies to investigate the efficacy of translocating displaced desert tortoises. Currently more than 2,000 displaced desert tortoises have been successfully translocated to this site and many more will be translocated over the coming several years. This site is crucial to desert tortoise conservation and management in Clark County. The people of Clark County have overwhelmingly supported desert tortoise conservation actions because, in part, displaced tortoises have been humanely provided a wild home at the LSTS. Threats to the integrity of the LSTS would jeopardize public support for tortoise conservation efforts.

The discussion of impacts of construction of a branch rail line in the Valley Modified corridor is inadequate because it fails to properly consider and address the regional and rangewide implications of loss of individuals and that loss*s impact on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range due to this activity.

6. The discussion of Impacts of Nevada Mostly Legal-Weight Truck Transportation Scenario (Section 6.3.1.1) is inadequate because it fails to properly consider and address the regional and rangewide implications of the loss of unique desert tortoise (Gopherus agassizii) populations and the genetic potential of these populations at the northern extremes of this species* range in the vicinity of the Repository and throughout Southern Nevada adjacent to I - 15 and U. S. 95. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in traffic on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range in the vicinity of the Repository and throughout Southern Nevada adjacent to I - 15 and U. S. 95 due to this activity. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in raven populations and their increased levels of predation on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range in the vicinity of the Repository and throughout Southern Nevada adjacent to I - 15 and U. S. 95 due to this activity. The discussion of the contribution of truck traffic related to this activity and its impact on desert tortoise populations is

lacking a consideration of noise and low frequency vibrations. This issue is of concern to Clark County because it is engaged in supporting significant conservation actions in areas adjacent to and in the regional vicinity of the Repository that may be indirectly impacted.

7. The discussion of the impacts of the Caliente-Las Vegas heavy-haul truck route (Section 6.3.3.1) is inadequate because it fails to properly consider and address the local, regional and rangewide implications of the loss of unique desert tortoise (Gopherus agassizii) populations and the genetic potential of these populations at the northern extremes of this species* range in the vicinity U. S. 93 in Coyote Springs Valley due to construction ctivities in upgrading the roads. It is inadequate because it fails to properly consider and address the local, regional and rangewide implications of increases in raven populations and their increased levels of predation on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range in the vicinity of U. S. 93 in Coyote Springs Valley due to construction activities and increased traffic during operation. The discussion of the contribution of truck traffic related to this activity and its impact on desert tortoise populations is lacking a consideration of noise and low frequency vibrations and their impacts on desert tortoises. This issue is of concern to Clark County because it is engaged in supporting significant conservation actions in areas adjacent to and in the regional vicinity of the Repository and along the Caliente-Las Vegas heavy-haul truck route and in the regional vicinity of the route that may be indirectly impacted.

8. The discussion of the impacts of the Sloan/Jean heavy-haul truck route (Section 6.3.3.2.1) is inadequate because it fails to properly consider and address the local, regional and rangewide implications of the loss of unique desert tortoise (Gopherus agassizii) populations and the genetic potential of these populations at the northern extremes of this species* range in the vicinity I - 15 in upper Ivanpah Valley due to construction activities in upgrading the roads and construction of the intermodal transfer station. It is inadequate because it fails to properly consider and address the local, regional and rangewide implications of increases in raven populations and their increased levels of predation on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range in the vicinity of I - 15 due to construction activities and increased traffic during operation. The discussion of the contribution of truck traffic related to this activity and its impact on desert tortoise populations is lacking a consideration of noise and low frequency vibrations and their impacts on desert tortoises. The discussion of the Sloan/Jean heavy-haul truck route is inadequate because it fails to consider that this route would pass through or near the Clark County Desert Tortoise Large-Scale Translocation Study Site (LSTS) west of Jean and west of I - 15. Clark County has invested significant resources in establishing this site and funding studies to investigate the efficacy of translocating displaced desert tortoises. Currently more than 2,000 displaced desert tortoises have been successfully translocated to this site and many more will be translocated over the coming several years. This site is crucial to desert

tortoise conservation and management in Clark County. The people of Clark County have overwhelmingly supported desert tortoise conservation actions because, in part, displaced tortoises have been humanely provided a wild home at the LSTS. Threats to the integrity of the LSTS would jeopardize public support for tortoise conservation efforts. This issue is of concern to Clark County because it is engaged in supporting significant conservation actions in areas adjacent to and in the regional vicinity of the Repository and along the Caliente-Las Vegas heavy-haul truck route and in the regional vicinity of the route that may be indirectly impacted.

9. The discussion of the impacts of the Apex/Dry Lake heavy-haul truck route (Section 6.3.3.1) is inadequate because it fails to properly consider and address the local, regional and rangewide implications of the loss of unique desert tortoise (Gopherus agassizii) populations and the genetic potential of these populations at the northern extremes of this species* range in the vicinity I - 15 and U. S. 95 due to construction activities in upgrading the roads. It is inadequate because it fails to properly consider and address the local, regional and rangewide implications of increases in raven populations and their increased levels of predation on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species* range in the vicinity I - 15 and U. S. 95 due to construction activities and increased traffic during operation. The discussion of the contribution of truck traffic related to this activity and its impact on desert tortoise populations is lacking a consideration of noise and low frequency vibrations and their impacts on desert tortoises. This issue is of concern to Clark County because it is engaged in supporting significant conservation actions in areas adjacent to and in the regional vicinity of the Repository and along the Caliente-Las Vegas heavy-haul truck route and in the regional vicinity of the route that may be indirectly impacted.

ATTACHMENT B

REVIEW OF THE TOTAL SYSTEM PERFORMANCE ASSESSMENT IN THE U.S. DEPARTMENT OF ENERGY VIABILITY ASSESMENT FOR THE YUCCA MOUNTAIN SITE

EIS001888

REVIEW OF TOTAL SYSTEM PERFORMANCE ASSESSMENT IN THE U.S. DEPARTMENT OF ENERGY VIABILITY ASSESSMENT FOR THE YUCCA MOUNTAIN SITE

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May 28, 1999

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EXECUTIVE SUMMARY

The Yucca Mountain site, located in Nevada about 100 miles northwest of Las Vegas, is being evaluated as a potential site for disposal of spent fuel for commercial nuclear power reactors and highly radioactive defense wastes. In the Energy and Water Appropriations Act of 1997, the U.S. Congress directed the U.S. Department of Energy (DOE), which has responsibility for the site evaluation, to prepare a comprehensive assessment of the viability of the project. The assessment was to include a total system performance assessment (TSPA) of the probable post-disposal safety performance of a repository at the site, based on available information.

The DOE issued its Viability Assessment (VA) report in December of 1998. The Department determined, on the basis of consideration of costs, schedules, technical uncertainties, and the results of the TSPA for the viability assessment (TSPA-VA), that Yucca Mountain is a promising site and that work should continue.

In January 1999, Clark County, Nevada, requested and authorized S. Cohen & Associates (SC&A) to independently review the TSPA-VA in order to evaluate the adequacy of the TSPA-VA as the means for characterizing repository performance. This is the report prepared as a result of the SC&A review.

The review addressed the technical factors that contribute to repository performance and its evaluation in the TSPA-VA. These include flow and radionuclide transport in the unsaturated and saturated hydrologic regimes; degradation of waste forms and waste packages; the thermal and geochemical environment in the vicinity of the packages; human uptake of radionuclides in the biosphere to result in radiation doses; and the computer codes used to produce the TSPA-VA results. SC&A reviewed the TSPA-VA (Volume 3 of the VA report), the supporting Technical Basis Document, which includes 11 topical chapters, and related documents such as the Nuclear Regulatory Commission's (NRC) Issue Resolution Status Reports.

The SC&A review found, as DOE itself found, that the TSPA-VA methodology and information base constitute a snapshot in an evolutionary process leading potentially to a finding that the site is suitable for disposal and thence to a License Application. Further development of TSPA methodology and data will be needed for a TSPA with substance and content to support a license application.

Principal findings of the SC&A review are summarized as follows.

- At this VA stage of the process toward evaluation of the suitability of the Yucca Mountain site for disposal, there were data deficiencies which limit confidence in some of the models used in the evaluations and in some of the parameter values used in the models.

- Some portions of the VA documentation did not meet DOE's objective to be clear and comprehensive in its description of TSPA-VA methodology, assumptions, and use of information. The VA provided only a limited description of the TSPA-VA computer codes and their use, and discussions of performance factors in the chapters of the Technical Basis Document were complex. Use of computer codes in the TSPA-VA is discussed in Appendix G of this report.

- DOE's selection of values for performance parameters was often based on limited data or recommendations from expert elicitations that were conducted in lieu of data. In some cases, such as waste package wall material corrosion rates (discussed in Appendix B), the base-case expected values used may not adequately represent the potential for radionuclide release and transport.

- DOE often selected features for TSPA-VA models that would produce high values for radionuclide release and transport. For example, it was assumed that the entire surface of the waste package is wetted when dripped on, that all seepage that contacts a package enters the package when the wall is penetrated, and that all of the waste form is exposed in a fuel rod with breached cladding.

- Some performance factors that could contribute to repository system performance, such as in-package dilution, were omitted from the TSPA-VA codes because the basis for characterizing performance parameter values was uncertain.

- The natural barrier system was assumed to make no contribution to repository system base-case performance except for dilution of radionuclide concentrations by a factor of 10 during transit of the saturated zone. The burden for repository system performance was therefore placed on engineered features of the system, i.e., waste package wall corrosion resistance and cladding integrity. Contributions of the natural barrier system to performance are discussed in detail in Appendix A; contributions of the waste package to performance are discussed in Appendix B.

- DOE's selections of corrosion rate values for the waste-package Corrosion Allowance Material (A516 carbon steel) may not adequately represent the corrosion-rate potential because they do not account for the effects of drip velocity, and formation of salts and chlorides. Similarly, the corrosion rates for the Corrosion Resistant Material, Alloy 22, may not adequately account for adverse crevice-corrosion conditions. Corrosion rates are discussed in Appendix B.

- The VA waste-package design is not an effective defense-in-depth design. Design options such as use of drip shields that were considered in the VA but not used in the TSPA-VA design have potential to significantly improve repository system performance.

- The TSPA-VA evaluations took credit for performance of cladding as an engineered barrier, but made assumptions that would tend to produce high values for release of radionuclides from the waste form. Such assumptions are concerned with the number of spent fuel rods with breached cladding, the exposed waste form area for each rod with breached cladding, and release of radionuclides with limited solubility, such as Np-237, from the waste form. Modeling of waste-form performance is discussed in Appendix C.

- For Tc-99 and I-129 (which are highly soluble, move with the ground water, and were found to be the only species to contribute to the 10,000-year dose rate), the assumption that natural system features contribute only limited dilution in the saturated zone to performance is realistic. The assumption is conservative for long-term dose rates, i.e., for 50,000 years and beyond, which are dominated by Np-237 and Pu-242, and for which some performance contributions from the natural system may be expected as a result of sorption on rock surfaces and the radionuclides' limited solubilities.

- A key feature of the models and computer codes used for the TSPA-VA analyses was uncoupling of thermal, hydrologic, chemical and mechanical phenomena that are known to be coupled. Coupled effects may be important to performance of a repository with the temperature and heat-load characteristics assumed for the TSPA-VA analyses, but the characteristics of coupling and their effects, and the effect of model uncoupling on the reliability of the TSPA-VA results, are uncertain. Coupling effects are discussed in Appendix E of this report.

- The results of the TSPA-VA evaluations also contain uncertainties associated with modeling of thermal hydrology, which is concerned with the effects of repository temperatures and heat loads on the characteristics of the rocks and hydrologic regime surrounding the emplacement drifts. At present, the data basis for this modeling is limited, and the validity of the models is uncertain. The

TSPA-VA assumed that thermal hydrologic processes are short-lived and do not permanently alter the hydrologic regime. Current information is insufficient to know if this is conservative or nonconservative. Thermal hydrology is discussed in Appendix D.

- The 10,000-year base-case dose-rate evaluation results, 0.04 mrem/yr, are principally dependent on assumptions concerning early failure of a waste package at 1,000 years and a climate change, which doubles the precipitation rate and causes an 80-meter rise in the water table, at 5,000 years. In the TSPA-VA models, assumptions concerning juvenile waste package failure and climate primarily affect the rate of seepage of water into the repository and the magnitude of the radionuclide source term.

- Use of conventional uncertainty characterization techniques showed that uncertainties in the base-case expected dose results span four to five orders of magnitude. This result is associated with the large number of parameters that have uncertainty ranges, either as a result of inherent, natural variability or as a result of current data uncertainties, including those resulting from lack of data.

- Overall, there is great "uncertainty in the uncertainty" associated with the TSPA-VA results. Uncertainty is present because of the many performance parameters that are genuinely variable and uncertain; because of uncertainty ranges assigned to parameters with limited data bases; and because of uncertainty ranges assigned to parameters that cannot have an experimental data basis, such as the number of juvenile package failures and future climate conditions. Uncertainty which cannot be explicitly characterized is also present in the TSPA-VA results because of uncertainty that the models used are appropriate and sufficient representations of actual conditions (e.g., uncertainties associated with uncoupling, in the models, of coupled phenomena). Experiments concerning the sensitivity of uncertainty to its various sources in TSPA evaluations might be done by running the computer codes with alternative models and parameter-value distributions.

- As acknowledged by DOE, the TSPA-VA methodologies and information base are not adequate to produce results suitable for licensing reviews. They are, however, significant improvements over previous TSPA evaluations, and they are close to the status required for licensing reviews. Improvements needed for licensing would include revision or refinement of model details, revision of parameter values as a result of data additions, and improvement of the quality-assurance basis for models, computer codes, and data. The results of TSPA evaluations for licensing reviews will, as demonstrated by the TSPA-VA results, depend strongly on the repository design features (e.g., waste package design and thermal loading) selected for licensing.

1.0 INTRODUCTION

Yucca Mountain, located in Nevada about 100 miles northwest of Las Vegas, is being evaluated as a potential site for disposal of spent fuel from commercial nuclear power reactors and other highly radioactive wastes. The wastes would be placed in high-integrity containers, which would be emplaced in mined excavations about 1,000 feet beneath the crest of the mountain.

The Yucca Mountain site has been under consideration as a potential disposal site since 1977. In the Nuclear Waste Policy Amendments Act of 1987, Yucca Mountain was designated as the only site whose suitability for disposal was to be evaluated. In the Energy and Water Appropriations Act of 1997, Congress directed the U.S. Department of Energy (DOE), which has responsibility for the site evaluation, to prepare an assessment of the viability of the project. The viability assessment (VA) was to be a comprehensive characterization of the project and the likelihood of its success. DOE issued its VA report in December of 1998 (DOE 1998a).

The DOE report found the project to be viable. The Department stated, in the Overview document, that *"DOE believes that Yucca Mountain remains a promising site for a geologic repository and that work should proceed to support a decision in 2001 on whether to recommend the site to the President for development as a repository"* (p. 36).

The VA directive from the Congress included a requirement for *"...a total system performance assessment based upon the design concept and the scientific data and analysis available by September 30, 1998, describing the probable behavior of the repository in the Yucca Mountain geological setting relative to the overall system performance standards."* In other words, the safety performance of the repository was to be evaluated, using currently available information, in comparison with radiation protection standards. The DOE VA report included a description of the total system performance assessment (TSPA) in Volume 3 of the five-volume report, and in a supporting Technical Basis Document, which included 11 chapters on the key technical topics involved in performance assessment (DOE 1998b).

This DOE assessment, known as the TSPA-VA, was preceded by three total system assessments. It will be followed by an assessment for the repository license application if the Yucca Mountain site is determined to be a suitable location for disposal.

In January 1999, Clark County, Nevada, requested and authorized S. Cohen & Associates, Inc. (SC&A) to independently review the TSPA-VA. The objective of the review was to evaluate the adequacy of the TSPA-VA as the means for characterizing repository performance. This is the report on that effort by SC&A.

The report includes a brief historical perspective on U.S. selection and implementation of geologic disposal (Section 2); a description of the Yucca Mountain site and the repository design concept that was the basis for the TSPA-VA (Section 3); a discussion of TSPA methodology and concepts (Section 4); a summary description of the key features of the TSPA-VA (Section 5); presentation and discussion of TSPA-VA results and their uncertainties (Section 6); and discussion of the findings of this review and assessment of the TSPA-VA (Section 7).

Detailed discussions of the key technical features of the TSPA-VA are provided in appendices. Appendix A discusses flow and radionuclide transport in the unsaturated and saturated zones. Appendix B addresses waste package degradation, and Appendix C addresses waste form degradation. Appendix D discusses the near field geochemical environment, Appendix E discusses thermal hydrology, and Appendix F discusses the biosphere. Computer codes used in the TSPA-VA are discussed in Appendix G. The topics of these appendices correspond to the chapters in the Technical Basis Document that this project's Statement of Work specified for review.

2.0 HISTORICAL PERSPECTIVE

Action by the Federal Government of the United States to permanently dispose of highly radioactive wastes began when the Atomic Energy Act of 1954 assigned responsibility for management and disposal of spent fuel from commercial nuclear power reactors to the Atomic Energy Commission (AEC). In 1957, in response to an AEC request, the National Academy of Sciences recommended geologic disposal in salt formations, and the AEC investigated this mode of disposal from 1962 to 1972. Alternative modes of disposal, such as the seabed, icesheets, and ejection to space, were evaluated in the period 1972-1974, but deep geologic disposal was retained as the preferred alternative.

The Nuclear Waste Policy Act of 1982 established the first comprehensive national policy on management and disposal of spent fuel and high-level radioactive wastes. The Act specified a process and schedule for siting two repositories and established the Office of Civilian Radioactive Waste Management in DOE to conduct the program. DOE was directed by the Act to begin receipt of spent fuel from commercial power reactors for disposal on January 31, 1998. DOE subsequently identified nine candidate disposal sites for the first repository: four in bedded salt, three in salt domes, one in basalt, and the Yucca Mountain site, for which the host rock is tuff.

In 1986, DOE recommended, and the President approved, three sites for detailed characterization: the Deaf Smith bedded salt site in Texas, the basalt site at Hanford, and the tuff site at Yucca Mountain. Also in 1986, the Secretary of Energy decided to indefinitely defer all work on a second site. In 1987, DOE announced a five-year delay (to 2003) in the inception of disposal because it had become apparent that more time than had been planned would be needed to obtain environmental permits and other approvals.

In 1987, Congress passed, and President Reagan signed into law, the Nuclear Waste Policy Amendments Act of 1987. This Act directed that only the Yucca Mountain site should be characterized to evaluate its suitability for development as a geologic repository. It also prohibited site-specific work directed toward siting a second repository and nullified DOE's proposal to site an interim storage facility at the Clinch River site in Tennessee.

The Nuclear Waste Policy Act of 1982 requires DOE to prepare a comprehensive site characterization plan and to submit it to the Nuclear Regulatory Commission (NRC) for review and comment. The plan for Yucca Mountain was issued in 1988. In 1989, after enactment of the Amendments Act and issuance of the site characterization plan, the plans and schedules for repository development were reassessed and the schedule for inception of repository operations was again revised, from 2003 to 2010.

The site characterization plan requires surface-based and underground testing and evaluations, laboratory studies, and analytical modeling of the repository system to evaluate its expected performance in comparison with regulatory standards issued by the NRC and the Environmental Protection Agency (EPA). The modeling also helps to guide and focus the site characterization and repository design activities. To aid evolution of the site characterization program and the engineered design of the repository, DOE performed and issued Total System Performance Assessment (TSPA) reports in 1991, 1993, and 1995. Each successive TSPA reflected additions to the site characterization and laboratory data base, which resulted in refinements and revisions of the engineered design and of the site characterization activities.

The TSPA-VA is therefore the fourth in a series of evolving characterizations of the potential performance of a repository at the Yucca Mountain site. It is a DOE management tool as well as a report on progress and prospects for a repository at Yucca Mountain. It is a snapshot in time of an evolving site data base and repository design concept. Data acquisition is continuing, and will continue even after the start of operations if a repository is built at Yucca Mountain. DOE is also investigating alternative engineered designs that might be used in the TSPA for the License Application (LA), if the site is approved for use for disposal.

3.0 TSPA-VA REPOSITORY SITE AND DESIGN CHARACTERISTICS

As required by the Energy and Water Appropriations Act of 1997, the basis for the TSPA-VA was the site data base and the engineered design concept that had been established as of September 30, 1998. This section describes the site and design features that are key to a TSPA and were used in development of the TSPA-VA. For TSPA purposes, a repository is composed of engineered and natural-system features that serve as barriers to release of radionuclides from the waste form and their transport to and through the environment in which the repository is located. The purpose of the TSPA is to analyze, individually and collectively, the performance of the various engineered and natural barriers to radionuclide release and transport.

The principal engineered barriers are:

- The waste form itself.
- Materials that contact and cover the waste form. For commercial spent reactor fuel, this material is known as cladding; for other waste forms expected to be emplaced in the repository, it would be a container, such as the container into which vitrified high-level waste is poured.
- The wall of the package that is used to emplace the wastes into the repository. In the TSPA-VA reference design, the package wall for commercial spent nuclear fuel (CSNF) is made up of an inner wall of a highly corrosion-resistant nickel alloy that is 2 cm (0.7 inches) thick, and an outer wall of steel that is 10 cm (4 inches) thick.

- The liner of the excavated drift that contains the emplaced waste packages. In the TSPA-VA reference design, the liner is concrete; the packages would be emplaced on steel supports set on a concrete floor.

- Any other design features included to enhance the performance of the Engineered Barrier System (EBS). The TSPA-VA considered, but did not include in the reference design, backfill to cover the waste packages; use of ceramic coatings on the waste packages; and use of drip shields which cover the tops of the horizontally emplaced packages and are intended to shield them from water that drips into the drift and would contact the packages.

The engineered elements of a repository also include equipment and facilities for operations, such as transporters for emplacing the waste packages. These engineered items are described in the VA and must be designed to meet NRC requirements, but they are not important to the post-operations safety performance of the repository.

Natural system features that are important to long-term repository safety performance are climate and the geologic, hydrologic, and geochemical characteristics of the site and its surroundings. The principal means by which radionuclides might be released from the repository and transported to and through the environment is through entry of water into the drifts where it can degrade the engineered barriers (e.g., corrode the waste package), leach radionuclides from the waste form, and then carry the radionuclides to the boundaries of the repository and beyond.

Some radionuclides, such as technetium-99 and iodine-129, are highly soluble and will travel at the same rate as the water, although concentrations may be affected by dilution. Other radionuclides, such as neptunium 237 and plutonium-239, have chemical properties that limit their solubility and also enable them to be attached to the geologic formations along the flow path.

The long-term safety performance of the repository will therefore depend on the specific characteristics of the site, the engineered design, and the properties of the radionuclides. Site characterization at Yucca Mountain has been aimed at evaluating, in terms of performance parameters, the site characteristics that are important to the TSPA, and design activities are aimed at providing the same function for the engineered features of the system. The key site and design features for the TSPA-VA are described below.

3.1 Characteristics of the Yucca Mountain Site

This section summarizes the key natural features of the Yucca Mountain site. The site characterization program has developed extensive, detailed information which is described in the VA documentation and in numerous supporting technical documents. The information presented here was abstracted from Volume 1, Introduction and Site Characteristics, of the VA report.

3.1.1 Geologic Features

Yucca Mountain is in the Basin and Range province of the United States. It is within the region known as the Great Basin, which encompasses nearly all of Nevada and parts of Utah, Idaho, Oregon, and California. The region is characterized by north-south aligned, mostly parallel, mountain ranges, formed by tectonic motion in which the crust on the western edge of the Basin is moving to the west relative to the eastern edge. This extensional motion has caused complex faulting; the mountains are basically tilted fault blocks with major faults along their sides. The valleys between the mountain ranges are filled with alluvium, which is the result of weathering and erosion of the mountains.

The rocks that make up Yucca Mountain were formed by explosive eruption of large volumes of volcanic rocks from sources to the north of the mountain. Yucca Mountain is composed of a sequence of such rocks, which were erupted between about fifteen and seven million years ago. The rocks are known as ash-flow tuffs, which are formed when hot volcanic gas and ash that was violently erupted flows at high velocity over the land surface.

The properties of the individual ash flows can vary widely, depending on the temperature and pressure of compaction and fusion of the erupted material. At high temperatures, welded tuff, which is a hard, brick-like rock with limited pore space, is formed. At lower temperatures, non-welded tuffs are formed. Non-welded tuffs have lower density, are brittle, and have higher porosity than the welded tuffs.

The stratigraphy of the rocks that make up Yucca Mountain is illustrated in Figure 3-1. Some of the layers are welded tuff, and others are non-welded. The Topapah Spring unit, which is a densely welded, fractured tuff, has been selected as the potential repository host rock. Directly beneath the Topapah Spring tuff in Yucca Mountain is the Calico Hills formation. None of the

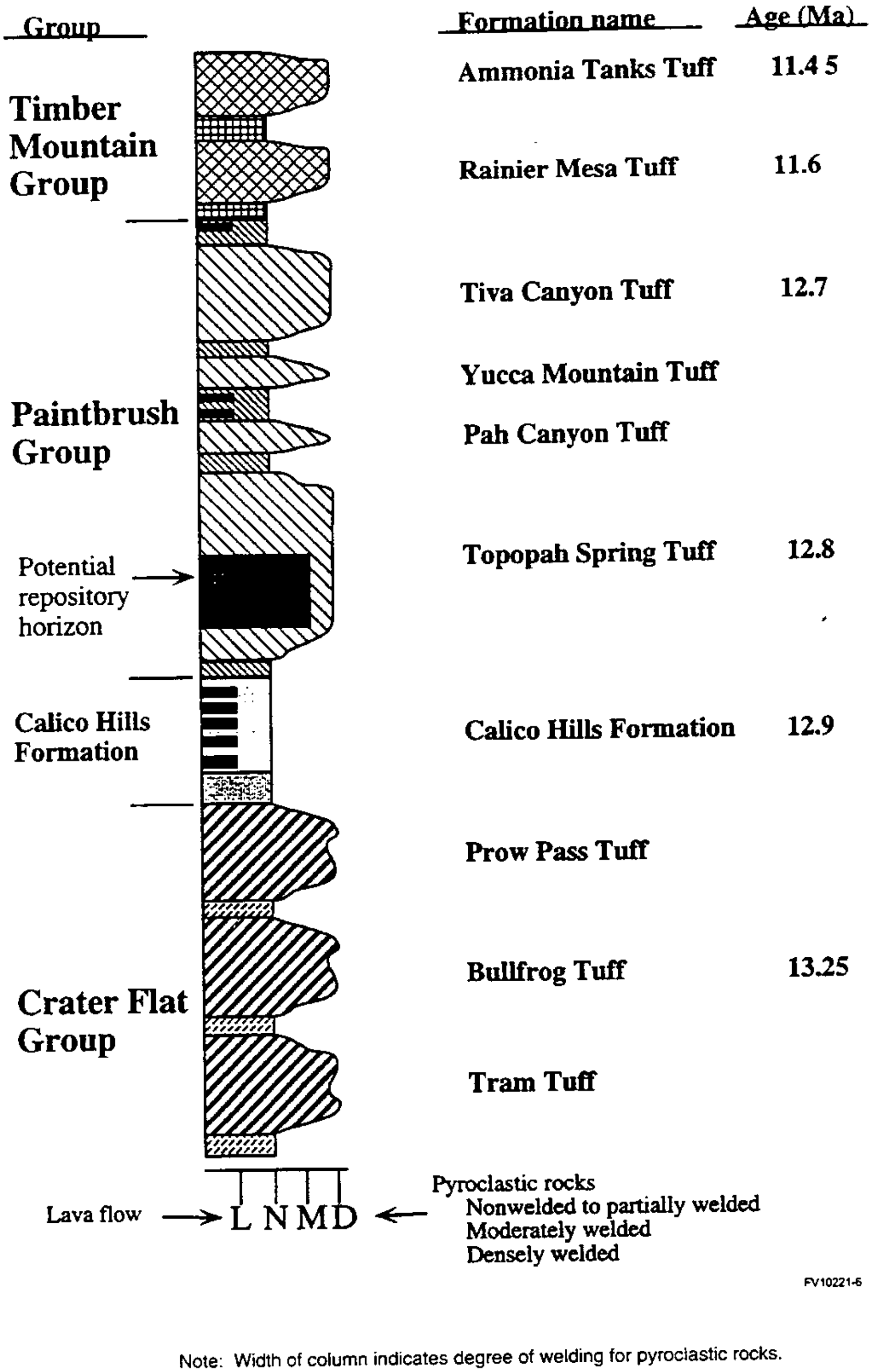

Figure 3-1. Principal Rock Stratigraphic Units at Yucca Mountain (Source: DOE 1998, Vol.1)

Calico Hills ash flows are densely welded. They contain zeolites, which are silicate minerals that have the ability to sorb (bind) radionuclides such as Np-237 and Pu-239. Such sorption could significantly slow the movement of radionuclides away from the repository.

As shown in Figure 3-2, there are many major faults in the Yucca Mountain region. The mountain is bounded by the Solitario Canyon fault to the west and the Bow Ridge fault to the east. The Ghost Dance fault runs through the mountain. DOE plans to locate the repository footprint between the Solitario Canyon and Ghost Dance faults. The Exploratory Studies Facility, which has been used for extensive testing and characterization at the repository horizon and whose location is shown in Figure 3-2, would be the eastern boundary of the repository.

Characterization of the site has included monitoring (since 1968) of recent seismic activity and characterization of faults to assess their past and future earthquake potential. The largest earthquake detected by the seismic monitoring network was the magnitude 5.6 event near Little Skull Mountain which occurred on June 29, 1992. Aerial photographs of faults within 100 km of Yucca Mountain were taken, and those suspected to have had movement during the past 2-3 million years (the Quaternary period) were examined and evaluated. Detailed, expert analysis of the data obtained has determined that the potential for fault displacement hazards is low. Over the next 100,000 years, the highest potential for movement is expected to be associated with the Solitario Canyon fault and the Bow Ridge fault. Potential adverse effects of movement on these faults will be mitigated by selection of the location of the surface facilities if the site is approved for use for disposal. Underground effects of any earthquakes are not expected.

3.1.2 Climate

The present climate in the Yucca Mountain region is characterized as semi-arid, with hot summers and mild winters. Average annual precipitation is in the range 100-250 mm (4 to 10 inches), and is episodic. The current conditions are the result of large-scale atmospheric circulation patterns and the high mountain ranges to the west, which are in the moisture pathway from the Pacific Ocean.

There is abundant evidence that the climate in the region has oscillated between glacial and interglacial periods in the past. Transition from the present interglacial period to a glacial period could begin in a few centuries or millennia. Three characteristic climate conditions can be characterized and were modeled for the TSPA-VA: dry (current conditions), with average precipitation of about 170 mm/yr; long-term average, with annual precipitation of about 300 mm/yr; and superpluvial, characteristic of the wettest and coldest glacial periods, with average annual precipitation of about 450 mm/yr.

Only a fraction of the precipitation on Yucca Mountain enters the interior of the mountain to potentially move to and through the repository. Much of the precipitation evaporates back into the atmosphere or is taken up by vegetation. Entry of precipitation into the mountain varies greatly with location, depending on the characteristics of the rocks at and beneath the surface. One of the principal site characterization activities has been to evaluate the distribution and rate of flow into the mountain.

3.1.3 Unsaturated Zone Hydrology

As a result of the semiarid climate in the region, there is a zone in the geologic formations, from the surface to the water table, in which the pore spaces are not fully saturated with water. At Yucca Mountain, this unsaturated zone (UZ) extends to depths well below the proposed repository depth: the water table is more than 2,000 feet below the surface, and about 1,000 feet below the proposed repository horizon.

The unsaturated zone serves to limit the amount of water that can contact the waste packages. Of primary interest for TSPA modeling is the rate of infiltration of water at the surface, the percolation flux that moves through the UZ to the repository horizon, and the fraction of the percolation flux that can seep into the repository drifts and contact the waste packages. Also of concern to TSPAs are flow rates and paths for water as it travels from the repository to the water table. During this part of the hydrologic transport, radionuclides contained in the water may be sorbed onto the zeolites in the Calico Hills formations.

The DOE has invested extensive site characterization effort of many types into characterization of flow and transport in the UZ, for purposes of developing a reliable three-dimensional model of the zone for use in the TSPAs. The characterization effort has produced a data base of the spatial distribution of infiltration and percolation flux, characterization of the geologic framework for the hydrologic regime, and evidence (from bomb-pulse chlorine 36 samples taken in the

Exploratory Studies Facility) that some water travels downward rapidly through fast-path channels.

The data show that, under current climate conditions, net infiltration in the vicinity of Yucca Mountain ranges between zero and about 40 mm/yr, with an average of about 4.9 mm/yr, and percolation flux at the repository horizon is in the range 1-20 mm/yr. Overall, the evaluations indicate that 6% or less of the annual precipitation becomes infiltration flux, and the percolation flux pattern at the repository horizon is not congruent with the infiltration flux pattern at the crest of the mountain because of lateral movement during transit to the proposed repository horizon. In general, flow in the highly complex geologic formations of Yucca Mountain occurs in fractures in the welded tuff formations and in the rock matrix of the non-welded tuff formations.

The hydrologic and geologic site characterization data have been used to develop a three-dimensional model of the UZ regime in Yucca Mountain. The model incorporates representation of moisture flow, capillary pressure effects, gas flow heat transfer, evaporation and condensation, moisture and gas flow travel times, and transport of conservative and reactive chemical species. The model grid covers approximately 43 sq km, centered on the repository footprint, which covers about three sq km. It has 1,500 element blocks and 25 hydrogeologically defined layers, which results in 39,000 element blocks to represent flow in the fractures and matrix. The UZ hydrologic model is discussed in more detail in Appendix A.

3.1.4 Saturated Zone Hydrology

The site characterization effort to date has shown that water that passes through the repository and travels to the saturated zone (SZ) beneath the repository will initially flow southeast and then turn south to flow toward Amargosa Valley. SZ flow in and near Yucca Mountain will occur in aquifers in fractured volcanic rocks. Along this flow path, approximately 15 km from the mountain, the volcanic rocks thin out and disappear because of the distance from their source, volcanic eruptions north of the mountain. The flow regime then becomes the valley-fill alluvium, which, in comparison to the fractured volcanic rocks, is a homogeneous porous medium. Along this pathway, radionuclides being transported from the repository may be sorbed onto the geologic medium or trapped in rock matrices. Radionuclide concentrations may be reduced by dispersion processes or dilution by mixing with uncontaminated water. The flow

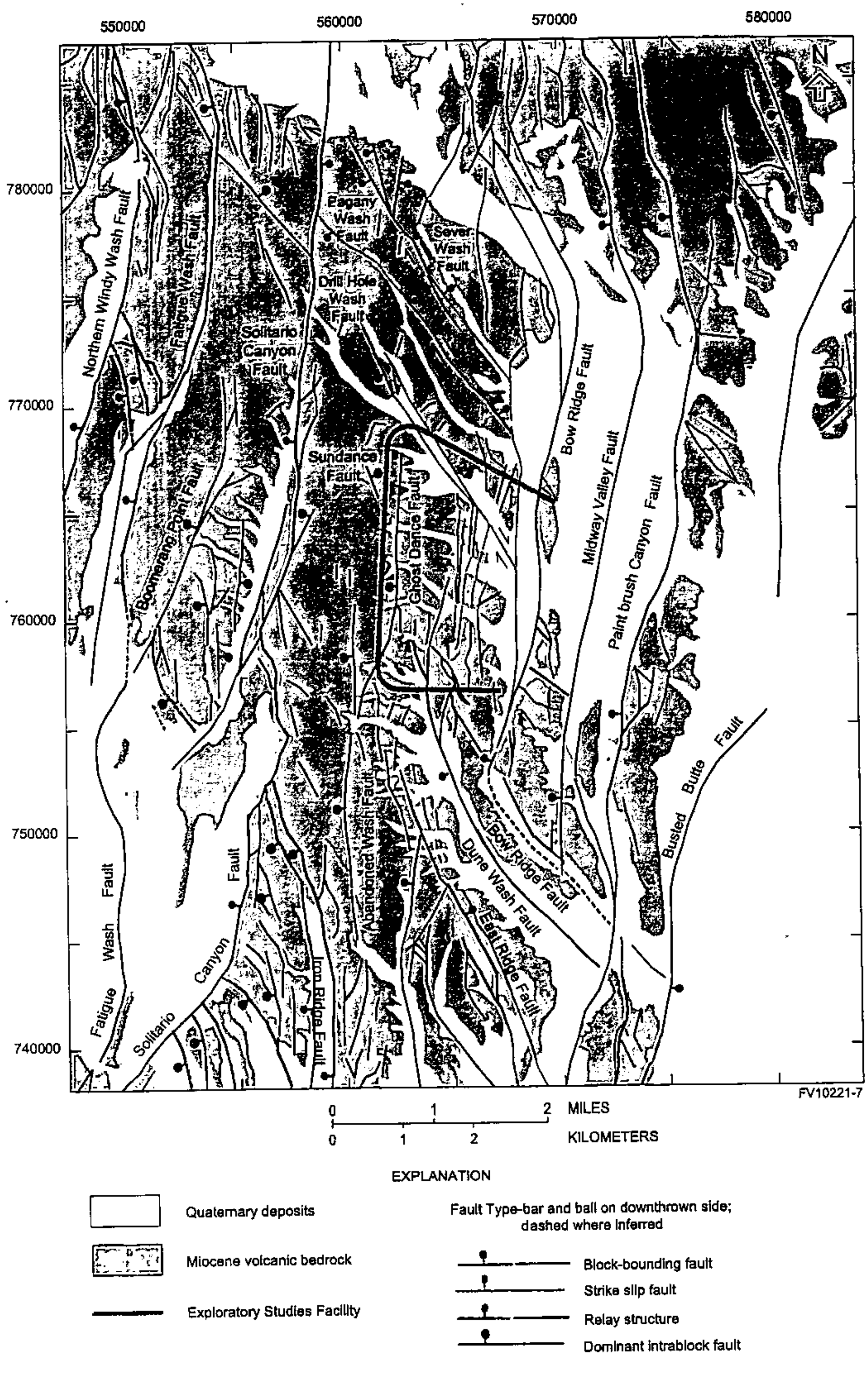

Figure 3-2. Faults in the Yucca Mountain Area (Source: DOE 1998a, Volume 1)

regime and the processes that can occur within it are shown in Figure 3-3, reproduced from Volume 1 of the VA document.

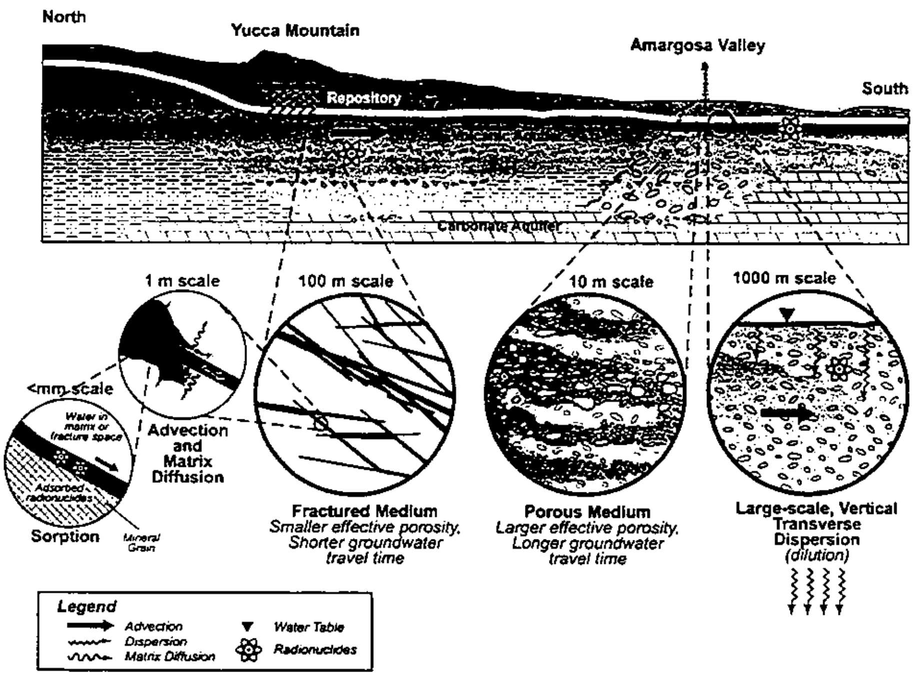

Figure 3-3. Cross Section Showing Conceptual Model of the Saturated Zone Flow System From Yucca Mountain to Amargosa Valley (Source: DOE 1998a, Volume 1)

Most of the data characterizing the SZ have been obtained near the proposed repository location because the EPA regulations that applied to the site before enactment of the Energy Policy Act of 1992, which directed EPA to develop new, site-specific standards for Yucca Mountain, called for evaluation of compliance with nuclide release across a boundary 5 km from the repository. DOE states in Volume 1 of the VA document that, even with many more data than are currently available, it would not be possible to define flow direction or radionuclide transport properties along the entire path length. There is, therefore, large uncertainty in the model representation of SZ flow rates, flow directions, geochemical conditions, and radionuclide transport properties such as sorption and chemical precipitation.

As a result of the uncertainties and recommendations from a panel of experts, DOE adopted for the TSPA-VA a stream tube model to represent flow from beneath the repository to Amargosa Valley and beyond. In this modeling approach, SZ flow and transport are represented in six stream tubes corresponding to the six subregions of the repository identified for the UZ modeling (see Appendix A). Hydrologic pathways and properties, and transport processes such as dispersion, dilution, and sorption, are modeled for each of the stream tubes. Details of the SZ modeling used in the TSPA-VA are provided in Appendix A.

3.1.5 Geochemical Environment

The chemical characteristics of the rocks and waters at the Yucca Mountain site can strongly affect transport of radionuclides from the repository to and through the environment. Movement of radionuclides can be retarded in comparison with water movement as a result of limited solubility in the chemical conditions of the water, which causes precipitation out of solution, or as a result of binding to surfaces and materials encountered along the flow paths. Conversely, some radionuclides have high solubility limits and limited sorption potential, so they travel with the water. Similarly, some radionuclides that would be expected to be held up along the flow path may actually travel with the water because they are present in and bound to colloids, which are very small particles suspended in the water.

Site characterization has shown that the chemistry conditions at and around Yucca Mountain are highly complex and heterogenous. Similarly, laboratory studies have shown that the solubilities and sorption capabilities of important radionuclides such as plutonium and neptunium are highly sensitive to their chemical environment. As a result, and because the temperature of the repository will change with time as a result of radioactive decay, the transport of radioactive species released from the waste forms will vary spatially and temporally within and beyond the repository boundary.

Experimental data have shown that actinium, americium, samarium, niobium, tin, thorium, and zirconium are strongly sorbed on surfaces in the Yucca Mountain rock units. Yucca Mountain rocks do not strongly sorb neptunium, protactinium, selenium, and uranium. Neptunium solubility is highly sensitive to local chemical conditions, and the behavior of plutonium is highly complex and primarily dependent on the local redox potential. Carbon, chlorine, iodine, and technetium have little or no sorption capacity under Yucca Mountain conditions.

Experimental data have shown that plutonium has migrated from the Benham weapon test site north of Yucca Mountain; these data illustrate the potential for colloidal transport where sorptive retention would nominally be expected.

The fracture and fault mineralogy of the unsaturated zone may be highly important to the performance of a repository at Yucca Mountain. As previously noted, water is expected to travel principally in the fractures in the welded tuff formations; radionuclides with good sorptive capacity may be trapped along these flow paths. Similarly, radionuclides may be retained by zeolites in the non-welded Calico Hills formations.

The fracture minerals in the rock formations below the water table vary significantly less in types and trapping potential than those in the unsaturated zone. In the SZ, therefore, a potentially important means of radionuclide holdup is diffusion into the matrix from the fracture flow paths.

Current radionuclide transport models for the UZ and the SZ exhibit significant uncertainty concerning the effects of geochemical conditions on transport rates. The models and their uncertainties are discussed in more detail in Appendix A. The geochemical environment in and near the repository drifts, which is known as the near field geochemical environment and is different from the general geochemical environment because of repository heat emissions and design features, is discussed in Appendix D.

3.1.6 Biosphere

For TSPA purposes, the biosphere is the human environment through which radionuclides released from the repository can move and produce radiation doses to the dose receptor(s). The dose that is calculated depends on the characteristics of the environment (soil, water, and air) and on the location, life style, and life practices of the dose receptor(s). It is necessary to characterize the site-specific biosphere and to select the characteristics of the dose receptor. The dose received will depend on how the radionuclides move through the environment and on how the receptor interacts with the environment.

The biosphere scenario adopted for the TSPA-VA base case assumed a reference person who is living 12 miles (20 km) from Yucca Mountain at the Lathrop Wells location of Amargosa Valley, which is the location of the current habitation closest to Yucca Mountain and down the hydraulic gradient which would transport radionuclides released from the repository. The reference person is an average adult who lives year-round at this location, uses a well as his primary water source, and has habits, such as consumption of local foods, that are representative of current habits of inhabitants of the region. Current inhabitants were surveyed as a basis for defining the food consumption of the reference person.

Since Yucca Mountain regulations that characterize the dose receptor to be considered have not yet been established, two other types of inhabitants were considered: a subsistence farmer, who takes all drinking water from a local well and consumes only locally produced foodstuffs, and a resident farmer, who also gets all drinking water from a local well but whose food consumption is only 50% locally grown.

The alternative dose receptors differ in their interactions with pathways that lead to radiation doses as a result of ingestion, inhalation, and exposure to external radiation. One of the pathways, for example, is from well water to soil by irrigation, from soil to dust by resuspension, and from dust to lungs via inhalation. TSPA-VA modeling of uptake from the pathways and calculation of doses used current practice and information concerning pathway parameters and dose conversion factors. Details of the review of the TSPA-VA modeling of the biosphere are presented in Appendix F.

3.2 Repository Design Features for the TSPA-VA

Repository design concepts have evolved significantly over the years of site evaluation. For example, the design concept used in the Site Characterization Plan issued in 1988 was vertical emplacement of canisters with small capacities into the floors of the tunnels and expected lifetimes on the order of 300-1,000 years. The basic concept used for the TSPA-VA was to emplace large, highly robust waste packages with design lifetimes on the order of tens of thousands of years horizontally in excavated drifts.

This section describes the engineered features of the repository that are of importance to safety performance and TSPA results. In general, these are design features that are specifically selected to aid waste isolation by delaying and diminishing opportunities for water to enter the drifts, to contact the waste form, leach out radionuclides, and transport the radioactivity to the environment.

In the reference EBS design that served as the basis for the TSPA-VA analyses, the principal design features that contributed to waste isolation were use of high waste package emplacement density so that repository temperatures would be high enough to boil water in the rocks and drive it away from the repository for as long as possible; use of a drift liner to help keep out seepage water for as long as the liner lasts; and use of a highly corrosion-resistant waste-package wall material which would be expected not to be penetrated by corrosion for very long periods of time. The TSPA-VA also characterized the potential performance of supplemental engineered features (use of backfill, drip shields over the waste packages, and ceramic coatings on the packages), but these features were not included in the reference design.

3.2.1 Assumptions That Provide the Basis for Design Parameter Values

Within the framework of the waste isolation strategy outlined above, assumptions were necessary as a basis for selecting design parameters. Key assumptions included the following:

- The Nuclear Waste Policy Act of 1982 limits the repository to a total capacity of 70,000 metric tonnes of uranium (MTU) as spent fuel or equivalent. The repository for the TSPA was assumed to contain 63,000 MTU of commercial spent fuel and 7,000 MTU equivalent of defense wastes, including vitrified high-level waste from defense production operations and spent fuel from naval reactors.

- Spent nuclear fuel assemblies from pressurized-water reactors will be, on average, 25.9 years out-of-reactor, with a 3.69 weight percent initial enrichment and a burnup value of 39.56 gigawatt-days per MTU. Spent fuel assemblies from boiling water reactors will be, on average, 27.2 years out-of-reactor, with 3.00 weight percent initial enrichment and a burnup value of 32.24 gigawatt-days per MTU.

- Commercial spent nuclear fuel (CSNF) will be emplaced in the repository in packages containing 21, 12, or 24 PWR assemblies per package and 44 BWR assemblies per package. There will be a total of 7,642 CSNF packages in the repository. There will be a total of 2,858 packages of defense wastes, for a repository total of 10,500 waste packages.

- The surface facilities, subsurface facilities, and waste package designs will be based on a reference areal mass loading range of 80 to 100 MTU/acre.

- The temperature of the drift walls will be limited to no more than 200 degrees Centigrade (392 degrees F).
- The temperature of the CSNF fuel cladding will be limited to 350 degrees Centigrade (662 degrees F).
- The repository's east-west boundaries will be between the Solitario Canyon fault and the Ghost Dance fault.

The reference repository and waste package designs that emerged from these and other assumptions important to safety for handling and emplacement operations are summarized below.

3.2.2 Repository Footprint

The repository layout that resulted from the assumptions concerning standoff from the faults, temperature limits, and the areal emplacement density is shown in Figure 3-4. The repository east-west width is about 1 km and the north-south length is about 3 km. The repository would be located at a depth about 1,000 feet below the crest of the mountain and 1,000 feet above the water table. The main emplacement drifts would be 18 feet (5.5 meters)in diameter; 104 drifts, totaling 67 miles of length, would be excavated to emplace the 70,000 MTU of wastes. The drifts would be spaced 90 feet (28 meters) apart, and the extraction ratio for the emplacement region of the repository would be 19.6%.

3.2.3 Waste Package Emplacement Configuration

Given the assumptions about waste-package capacity, each package would be about 6 feet (2 meters) in diameter and about 18 feet (6 meters) long to accommodate the dimensions of the intact CSNF assemblies. Details of the package dimensions will vary because of variations in assembly dimensions.

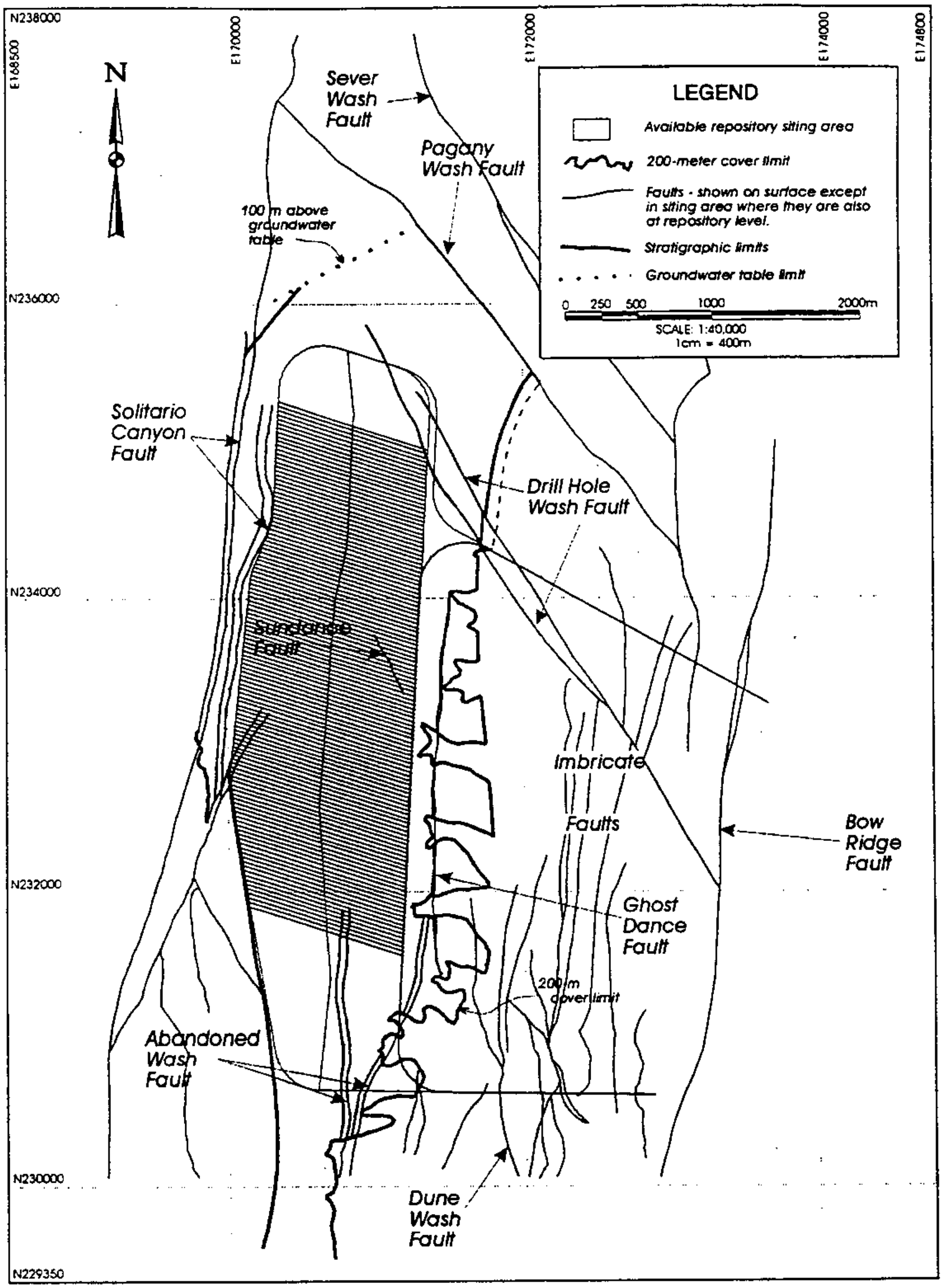

Figure 3-4. Repository Siting Limits (Source: DOE 1998a, Volume 2)

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A cross-section diagram of a typical waste package emplaced in a drift is shown in Figure 3-5. The package will be emplaced horizontally on steel V-shaped supports, which in turn are set on a concrete invert and pier. The drift is lined with concrete. The invert completes a concrete ring around the perimeter of the drift and also provides a roadbed for construction and emplacement operations.

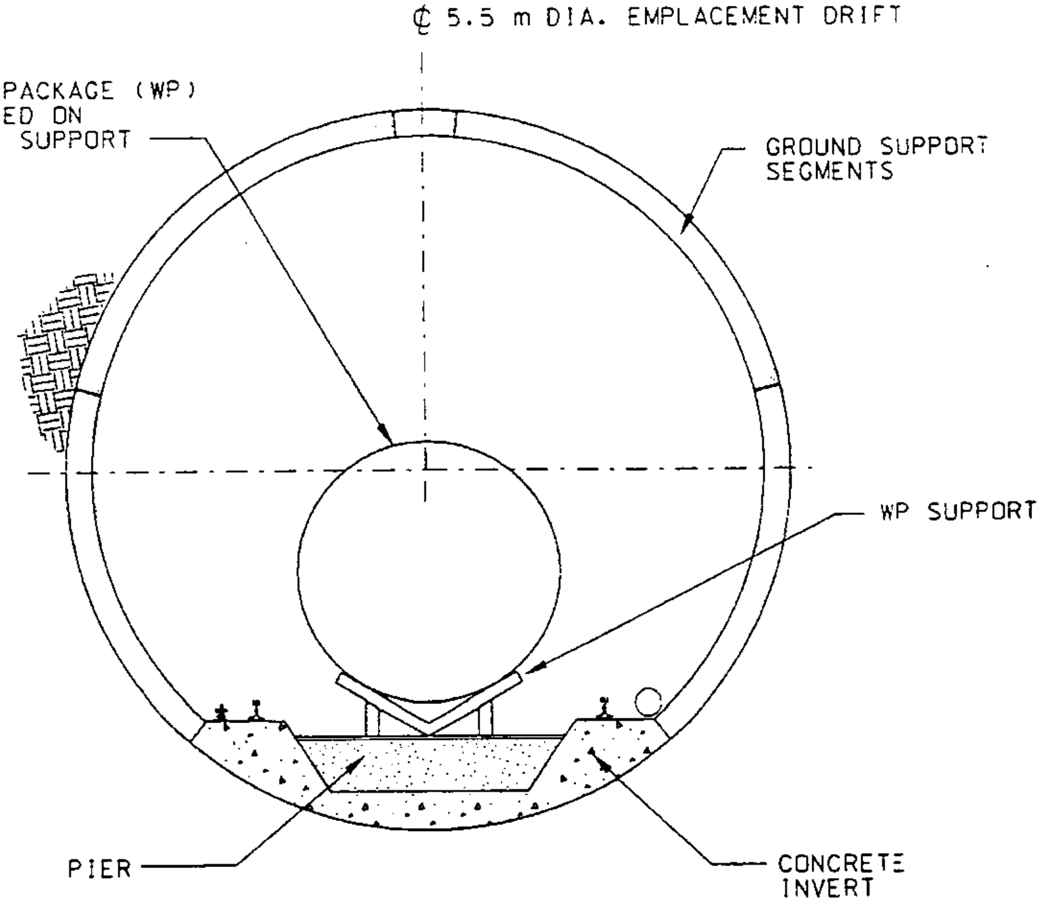

Figure 3-5. Emplacement Drift Section at Waste Package Support Location (Source: DOE 1998a, Volume 2)

3.2.4 Waste Package Design

A perspective diagram of the waste package design for disposal of 21 PWR spent fuel assemblies is shown in Figure 3-6. Packages for disposal of BWR spent fuel assemblies and for disposal of defense wastes are conceptually similar in design. As previously indicated, the packages for disposal of PWR and BWR spent fuel would be about 6 feet in diameter and 18 feet long. Packages for disposal of defense wastes would be about 6 feet in diameter and 10 feet long.

The design features of most importance to the TSPA-VA are the materials selected for the waste package walls, identified in Figure 3-6 as the inner and outer barriers. Each package has an inner barrier of Alloy 22, which is a high-nickel, highly corrosion-resistant alloy intended in the design to provide the principal barrier to penetration of water into the interior of the package. The outer barrier, which in the reference design is A 516 steel, is intended primarily to provide shielding and package strength. The reference design thickness of the outer barrier is 4 inches (100 mm); the inner barrier is 0.7 inches (20 mm) thick.

3.2.5 Design Options

Many other possible design concepts and parameter values are identified and discussed in some detail in the VA documentation (Volume 2, Section 8 of DOE 1998a). The options include alternative design features, such as use of drip shields or ceramic coatings to defer the time at which water can contact the waste package wall and begin to penetrate it, and alternative design strategies. Although not part of the VA reference design, the effects of backfill, drip shields, and ceramic coatings on repository performance were evaluated in the TSPA-VA.

Alternative strategies include use of a low emplacement density or long-term cooling before emplacement, either of which would reduce the areal thermal loading and would be intended to reduce performance issues and uncertainties arising from the high temperatures associated with the VA reference design. DOE is proceeding to characterize and evaluate some of the options, which might be implemented in the design for the license application if the site is found suitable for use for disposal.

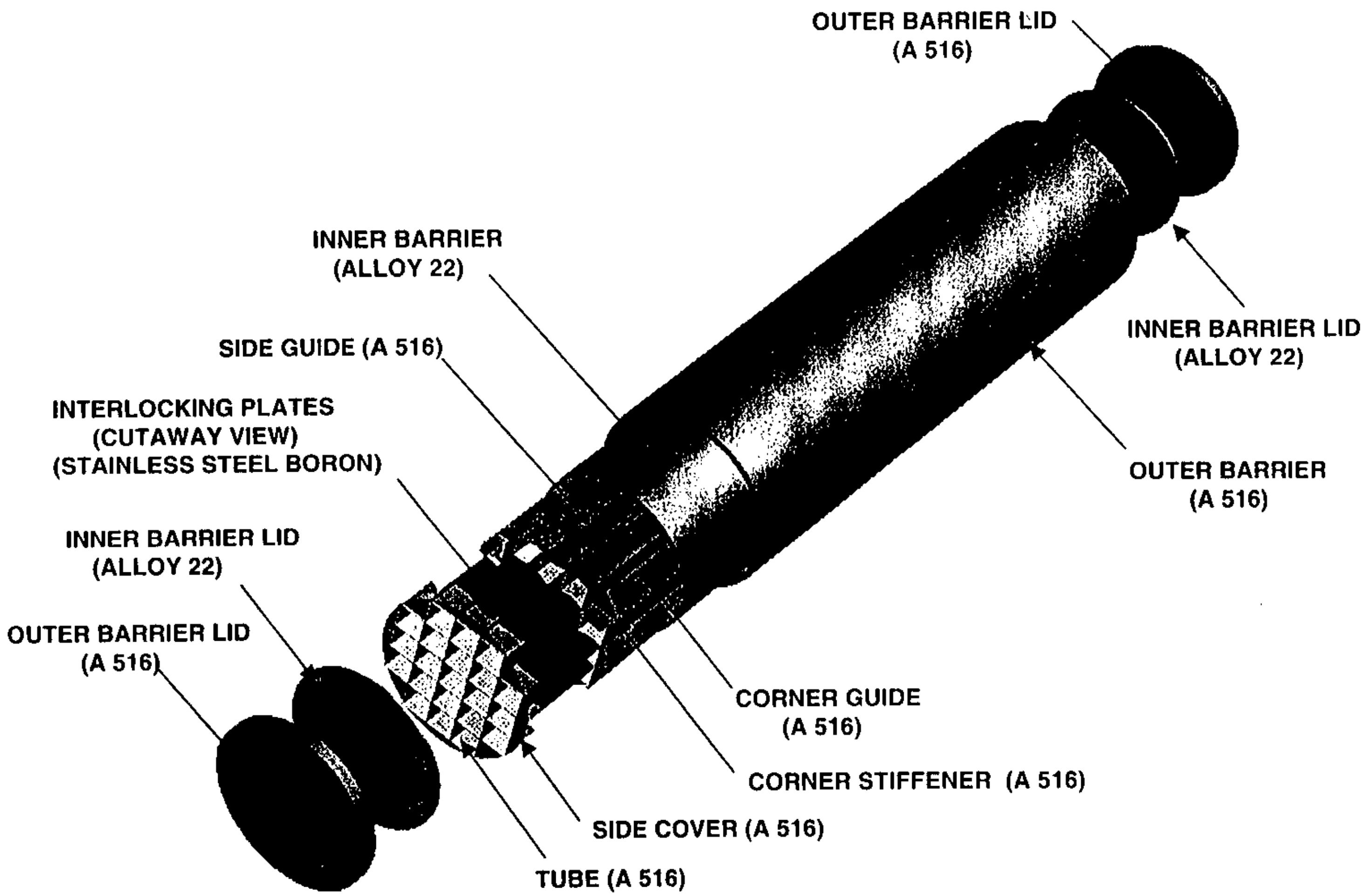

Figure 3-6. Waste Package for 21 Pressurized-Water Reactor Uncanistered Fuel Assemblies (Source: DOE 1998a, Volume 2)

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4.0 TSPA CONCEPTS AND METHODOLOGY

This section presents an overview of TSPA concepts and methodologies that are the basis for DOE's implementation of performance assessment in the TSPA-VA. As previously noted, the TSPA-VA is a snapshot in time of performance evaluation for the VA reference design, data base, and models that were available for the purpose. If the Yucca Mountain project proceeds to the stage of preparing a license application for a repository at Yucca Mountain, the details of the TSPA for the application would likely be different from those of the TSPA-VA.

The basic TSPA principles used for the TSPA-VA have been adopted in radioactive waste disposal programs throughout the world as the means for forecasting the post-disposal performance of a repository. For any given repository natural setting and engineered design, the process involves five basic steps:

- Develop and screen scenarios of conditions and factors important to performance. Scenarios address features, processes, and events that can affect repository performance, such as average annual precipitation rates and changes therein.
- Develop analytical models to represent the factors important to performance. The models are usually implemented as computer codes.
- Assign values to performance parameters in the models. Some parameters will be single-valued, such as the density of water at a given temperature; others will have uncertainty ranges because of inherent variability or lack of certain knowledge of the value.
- Implement the models by operating the computer codes.
- Interpret and apply the results to purposes such as identification of additional data needs or assessment of compliance with regulatory standards.

For a proposed repository at Yucca Mountain and its geohydrologic setting, DOE selected four basic performance strategy factors:

- Limit the potential for water to contact the waste packages
- Design the waste package for a long lifetime

- Seek a low rate of release from breached waste packages

- Seek radionuclide concentration reduction during transport from the repository to and through the environment

This strategy was implemented by identifying principal performance factors and components of the TSPA modeling configuration as shown in Table 4-1. As indicated in this table, the model components are aligned with the Key Technical Issues that NRC has identified as the basis for review of DOE's assessments of repository performance. Parameter values and subsystem models were developed for each of the 19 principal performance factors listed in Table 4-1.

Each of the performance factors listed in Table 4-1 can be characterized as a driver or an inhibitor of radionuclide release and transport:

- Precipitation, infiltration, seepage, and dripping bring water that can cause release to the waste packages

- Waste package humidity, temperature, and chemistry drive the rate of attack on the inner and outer waste package barriers, which are principal inhibitors of radionuclide release

- Inhibition of release is also accomplished by the integrity of the spent fuel cladding, resistance to dissolution of the waste forms, and the limited solubility in water of Np-237

- Radionuclide mobility during transit from the repository to and through the environment is aided if the radionuclides are attached to colloids but inhibited if they become sorbed onto surfaces along the flow path

- Transport of radionuclide-bearing water from breached packages brings the radionuclides to the dose receptor location through pathways in the unsaturated and saturated zones

- Dilution during transit and pumping will reduce the radionuclide concentrations in water used by the dose receptor

- Biosphere transport will bring radionuclides into contact with the dose receptor in accord with his/her life style and practices

Table 4-1. Principal Factors Affecting Expected Postclosure Performance for the Viability Assessment Reference Design (Source: DOE 1998a, Volume 3)

Attributes of the Repository Safety Strategy[a]	Principal Factors[a]	TSPA Model Components	NRC Key Technical Issue[b]
Limited water contacting waste packages	Precipitation and infiltration of water into the mountain	Unsaturated Zone Flow	Unsaturated and Saturated Flow under Isothermal Conditions
	Percolation to depth		
	Seepage into drifts	Seepage	Repository Design and Thermomechanical Effects
	Effects of heat and excavation on flow		
	Dripping onto waste package	Thermal Hydrology – Mountain Scale Thermal Hydrology-Drift Scale	Thermal Effects on Flow
	Humidity and temperature at waste package		
Long waste package lifetime	Chemistry on waste package	Near-Field Geochemical Environment	Evolution of the Near-Field Environment
	Integrity of waste package outer barrier	Waste Package Degradation	Container Life and Source Term
	Integrity of waste package inner barrier		
Low rate of release of radionuclides from breached waste packages	Seepage into waste package		
	Integrity of spent nuclear fuel cladding	Waste Form Degradation Radionuclide Mobilization and Engineered Barrier System Transport	
	Dissolution of UO_2 and glass waste form		
	Solubility of neptunium-237		
	Formation of radionuclide-bearing colloids		
	Transport within and out of waste package		
Radionuclide concentration reduction during transport from the waste packages	Transport through unsaturated zone	Unsaturated Zone Transport	Unsaturated and Saturated Flow under Isothermal Conditions and Radionuclide Transport
	Transport in saturated zone	Saturated Zone Flow and Transport	
	Dilution from pumping		
	Biosphere transport	Biosphere Transport and Uptake	

[a]See Rev. 2 of the DOE repository safety strategy (DOE 1998)

[b]NRC realigned its prelicensing program to focus all its activities on resolving the 10 key technical issues it considered to be most important to repository performance. The Key Technical Issues consist of the following: 1) Total System Performance Assessment (NRC 1998a); 2) Unsaturated and Saturated Flow Under Isothermal Conditions (NRC 1997e; 1997f); 3) Evolution of the Near-Field Environment (NRC 1997c); 4) Container Life and Source Term (NRC 1998b); 5) Repository Design and Thermal-Mechanical Effects (NRC 1997a); 6) Thermal Effects on Flow (NRC 1997b); 7) Radionuclide Transport (Sagar 1997); 8) Structural Deformation and Seismicity (NRC 1997d); 9) Igneous Activity (NRC 1998d); 10) Activities Related to Development of NRC High-Level Radioactive Waste Regulations (Sagar 1997). The first nine of these directly or indirectly related to performance assessment. The last one also relates to performance assessment to the extent this tool is used as a basis for setting and showing compliance with regulatory standards. These key technical issues are summarized in NRC staff reports (such as Sagar 1997) and a series of issue resolution status reports, the primary mechanism by which NRC will provide DOE with feedback on the resolution of the key technical issues.

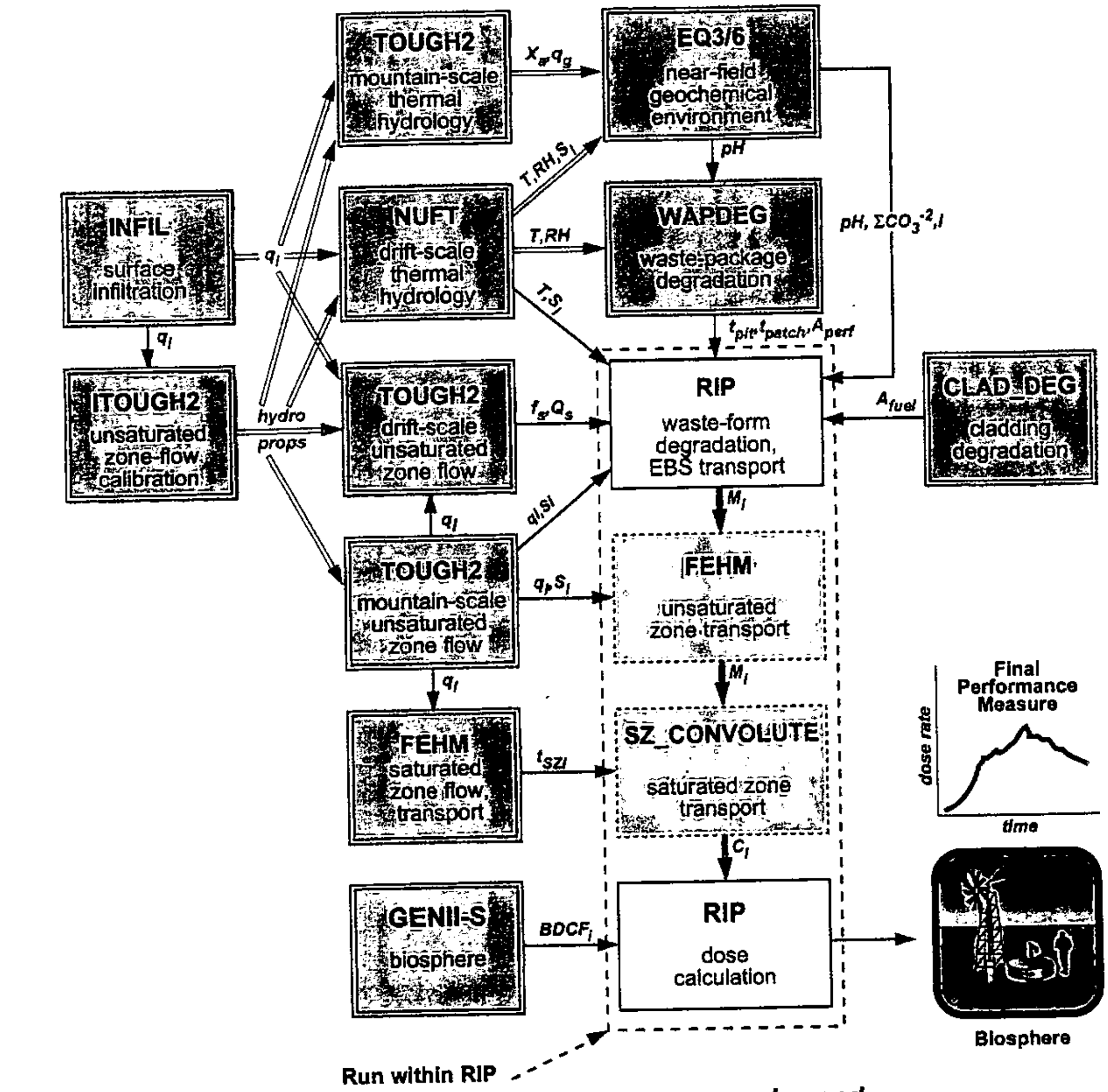
The specific characteristics of each of these drivers or inhibitors of radionuclide release and transport are represented in the parameters and models used in the TSPA.

As noted in Section 3, one of the features of the repository design used in the TSPA-VA was an initial high thermal loading, i.e., 85 MTU/acre, with a drift wall temperature of 200 degrees C. The performance objective for this design concept is to drive the water in the geologic formations around the repository away from the drifts for as long as possible, while radionuclides in the wastes decay and heat emissions from the waste packages decrease. An adverse consequence of the concept is that it produces high temperature levels and temperature gradients, which will accelerate degradation processes and can change the characteristics of the geologic formations. The thermal, chemical, hydrologic, and mechanical factors associated with the high temperatures are coupled in highly complex ways that are difficult to model and characterize with reliable parameter values. The modeling approach used in the TSPA-VA uncoupled these factors, thereby adding to the uncertainty of the TSPA-VA results.

The computer codes and their configuration used in the TSPA-VA are shown in Figure 4-1. As indicated in this diagram, thermal hydrology factors and UZ flow were modeled at both mountain (large) and drift (small) scales. The Repository Integration Program (RIP) code receives input from the codes for the individual performance factors and processes the inputs to calculate radiation doses to the dose receptor(s). Many of the codes shown in Figure 4-1 were developed or adapted specifically for use in the TSPA-VA; details are provided in the VA documentation and supporting documents. A technical discussion of the codes is provided in Appendix G of this report.

The codes used in the TSPA-VA include considerations of uncertainty and produce characterizations of uncertainty in the assessment results. Four types of uncertainty are considered: parameter value uncertainty, conceptual model uncertainty, numerical model uncertainty, and uncertainty in the occurrence of future events such as earthquakes or human intrusion into the repository. For the TSPA-VA, there was considerable uncertainty in most of the component models and in parameters that represent performance factors that are inherently variable or had a sparse data base. Techniques such as Monte Carlo sampling are used to characterize uncertainty in the results of the assessments; uncertainties in the peak dose rate results of the TSPA-VA evaluations spanned four to five orders of magnitude and are discussed in Section 6 of this report.

Nine radionuclides were considered in the TSPA-VA evaluations: C-14, I-129, Np-237, Pr-231, Pu-239, Pu-242, Se-79, Tc-99, and U-234. These are the nuclides that prior TSPA work has



OUTPUT Parameters

T	Temperature	Q_S	Seep flow rate
RH	Relative humidity	pH	pH
S_l	Liquid saturation	ΣCO_3^{-2}	Carbonate concentration
X_a	Air mass fraction	I	Ionic strength
q_g	Gas flux	t_{pit}	Initial-pit-penetration time
q_l	Liquid flux	t_{patch}	Initial-patch-penetration time
q_i	Infiltration flux	A_{perf}	Perforated container area
M_i	Radionuclide mass flux	A_{fuel}	Exposed fuel area
C_i	Radionuclide concentration	t_{SZi}	Saturated zone transport time
f_S	Fraction of WPs with seeps	$BDCF_i$	Biosphere dose conversion factor
		EBS	Engineered Barrier System

Legend

- *External Process Model*
- *RIP Cells*
- *Rip Calls External Code*
- *Response Surface Between Process Models*
- *Response Surface from Process Model to RIP*
- *Between RIP Cells and External Code*

Figure 4-1. Total System Performance Assessment for the Viability Assessment Code Configuration: Information Flow Among Component Computer Codes (Source: DOE 1998a, Volume 3) shown to have the most potential to produce dose effects in the future because of their long half-lives, their high dose consequences (e.g., Np and Pu), or their high mobility in the environment (e.g., Tc-99, and I-129. As discussed in Section 6 of this report, the highly mobile Tc-99 and I-129 were found to be the source for doses in the 10,000 year time period; Np-237 dominated doses in the period tens-of-thousands to about 300,000 years; and Np-237 and Pu-242 were dominant in the period from 300,000 to one million years.

5.0 KEY FEATURES OF THE TSPA-VA BASE CASE MODELS

This section summarizes key features of the performance factors and computer codes that were described in Section 4 and were used to implement the TSPA-VA. The descriptions are based on information contained in Section 4 of the TSPA-VA document, Volume 3 of the VA report. Additional details are provided in the appendices of this report; highly detailed discussions were provided in the chapters of the Technical Basis Document for the VA, and in topical reports that were discussed as references in the Technical Basis Documents.

5.1 Climate

The TSPA-VA assumed there would be three characteristic climate regimes in the future at Yucca Mountain, with periodic recurrence intervals: dry (current conditions), long-term average, and superpluvial. Present conditions were assumed to prevail for the next 5,000 years. Long-term average conditions were assumed to persist for 90,000 years each time they occur, and superpluvial periods were assumed to last for 10,000 years.

Average precipitation rates in the long-term average and superpluvial periods were assumed to be two and three times, respectively, higher than present rates, which average about 170 mm/yr. Two superpluvial periods, in which glaciation is at a maximum and temperatures are a minimum, were assumed to occur in the next million years: one at about 300,000 years and the other at 700,000 years. Between the superpluvials, the 5,000-year dry periods and the 90,000-year long-term average periods alternate. Under these assumptions, about 90% of the next million years experiences the long-term average climate.

The water-table level was assumed to respond to the changes in precipitation, rising by 80 meters from present levels during long-term average climates and 120 meters during the superpluvial

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periods. One of the modeling consequences of the water-table rise is that the UZ flow path length is shortened. DOE's modeling of climate change is discussed in more detail in Appendix A, as part of the discussion of the hydrologic regime.

5.2 Unsaturated Zone Flow and Infiltration

On the basis of site characterization data, the repository footprint was divided into six characteristic UZ flow and infiltration zones. Three three-dimensional steady-state flow models were developed for fracture and matrix flow under current climate conditions and were extrapolated to the wetter climate conditions. Average infiltration rates for the present, long-term average and superpluvial climate conditions were assumed to be about 7.7, 42, and 110 mm/yr, respectively. Note that the infiltration rates are assumed to increase by factors of about 6 and 14 from the present rate, while the precipitation rate increases only by factors of 2 and 3. UZ flow and infiltration are discussed in more detail in Appendix A.

5.3 Drift Scale Seepage

Characterization of seepage into the drifts was based on modeling of a three-dimensional, heterogeneous fracture continuum surrounding the drifts. The seepage flow rate and fraction of the packages that are affected by seeps were modeled in terms of percolation flux, i.e., the water flux that arrives at the repository horizon after infiltration at the surface and flow through the UZ above the repository. Percolation flux was characterized for each of the six regions of the repository footprint and the three climate conditions, based on site data and the climate model.

The modeling showed that about 10% of the waste packages would be exposed to seeps during the dry-climate period, 30% would be exposed to seeps during the long-term average climate conditions, and 50% would be exposed during the superpluvial periods. The estimates of the fraction of the packages exposed to seeps had a very high uncertainty range in the TSPA-VA evaluations.

5.4 Thermal Hydrology

Thermal hydrology models are used to calculate temperatures (waste package surface, waste form, drift wall) and relative humidities to provide information needed for other models such as the waste package degradation model and the near field geochemical environment models. Standard models of heat transfer and data concerning the physical properties of the materials involved are used to calculate these parameters. Thermal hydrology modeling is discussed in more detail in Appendix E.

5.5 Near Field Geochemical Environment

The near-field geochemical environment models calculate the time-dependent evolution of the gas and water compositions that interact with the waste package, the waste form, and other materials in the drift. The evolution of changes in gas and water composition is modeled as a sequence of steady-state conditions. As noted previously, the chemical, thermal, hydrologic, and mechanical factors important to the near field environment are coupled, but an integrated model of the coupling and its effects can not be developed.

Five separate but interacting models were used for the near field geochemical environment:

- Gas, water, and colloid compositions as they enter the drift
- Composition of the in-drift gas phase
- Chemistry of in-drift interactions of water with the solids and gases in the drift
- In-drift colloid compositions
- In-drift microbial communities

The near-field geochemical environment models are connected to other component models. The near-field models receive input from the UZ and thermal hydrology models and from design parameters; they provide outputs to the waste package corrosion model, the waste form model, the UZ radionuclide transport model, and the nuclear criticality model. Modeling of the near field geochemical environment is discussed in more detail in Appendix E.

5.6 Waste Package Degradation

Modeling of waste package degradation used groups based on waste type contained in the package, whether the packages were dripped on or not dripped on, and their location in the repository. Uncertainty in the corrosion rate of the Alloy 22 corrosion-resistant barrier in the waste package wall was modeled, and the expected-value base case assumed a single juvenile waste package failure occurs 1,000 years after disposal. Corrosion of waste package materials is assumed to occur via pits and patches that always encounter seeping water. Waste package degradation is discussed more extensively in Appendix B.

5.7 Cladding Degradation

Mechanisms included in models for degradation of fuel rod cladding on commercial spent nuclear fuel included some pre-disposal failures, creep failure of zircaloy at high temperatures, total failure of rods clad with stainless steel, and long-term general corrosion failure. Breaching of cladding was assumed to expose all of the waste-form surface in the rod. Cladding degradation is discussed in detail in Appendix C, as part of the discussion of waste form degradation.

5.8 Waste Form Degradation and Mobilization

Dissolution of CSNF was modeled to be a function of pH, temperature, and total dissolved carbonate; model parameters were based on experimental data. Dissolution of vitrified high-level defense waste was modeled as a function of surface temperature and water pH, and a dissolution rate constant for metals was used for degradation of the defense spent fuel from the N-Reactor. Under the assumption that all spent fuel is exposed and wetted for rods with breached cladding, the spent fuel would be totally dissolved in about 1,000 years. Dissolution of uranium dioxide fuel is known to result in formation of secondary minerals which can trap species such as Np-237 and reduce their release, but credit for this phenomenon was not taken in the TSPA-VA modeling.

5.9 Engineered Barrier System Transport

Transport in the EBS was modeled as a series of connected mixing cells, with one cell combining the waste form and waste package, and three pathway cells representing the invert, in order to reduce numerical dispersion in model calculations. The models did not include factors that could defer and decrease radionuclide release after a waste-package wall is breached, such as low seepage rates, fractions thereof that get into the package interior, and in-package dilution. Sorption and diffusional transport was assumed for radionuclide movement through the concrete invert. Consistent with data from the Benham weapon test at the Nevada Test Site, a small fraction of the plutonium mobilized was assumed to be attached to mobile colloids.

5.10 Unsaturated Zone Transport

The radionuclide transport model for the unsaturated zone is based on the flow model for that zone. Three flow fields, the same climate conditions, and a dual-permeability geologic regime are assumed. Radionuclide movement is modeled using a three-dimensional particle tracking model. Sorption is assumed to occur for Np-237, Pu-239, and Pu-242. Matrix diffusion and dispersion are also assumed to occur. Transport of radionuclides in the UZ is discussed in more detail in Appendix A.

5.11 Saturated Zone Flow and Transport

Flow in the saturated zone is simulated using a coarsely discretized three-dimensional model which establishes the general plume direction and flow path in the geologic media. Radionuclide transport occurs in six one-dimensional stream tubes corresponding to the six area regions defined for the repository footprint. Based on the recommendations of the saturated zone expert elicitation panel, the specific discharge in all stream tubes was assumed to be 0.6 m/yr, and a dilution factor probability range, with a mean value of 10, was assumed to apply to all of the stream tubes. Saturated zone transport of radionuclides is discussed in more detail in Appendix A.

5.12 Biosphere Transport

Water used by the dose receptor was assumed to be drawn from a well 20 km (12 miles) downgradient from the repository. Dilution was assumed not to occur during pumping, so the radionuclide concentration in the water emerging from the well is the same as the stream tube concentration at the withdrawal location. The dose receptor uses the water in accord with the life styles and habits assigned to the average adult living in Amargosa Valley. The dose rate to the individual is then calculated as the product of the biosphere dose-conversion factor and the saturated zone radionuclide concentration at the withdrawal location. Biosphere modeling in the TSPA-VA is discussed in more detail in Appendix F.

6.0 TSPA-VA RESULTS AND UNCERTAINTIES

DOE produced the following categories of TSPA-VA results:

- Deterministic results of the TSPA-VA base case
- Results of uncertainty analyses using Monte Carlo techniques
- Results of analyses to assess the sensitivity of performance to uncertainty in parameter values
- Assessments of the effect of disruptive events on performance
- Assessment of the effect of design options on performance

Collectively, these assessment results address the expected performance of the repository, the role of the various performance factors in producing the expected performance, factors that could alter expected performance, and the uncertainty in expected performance. This section of this report summarizes the repository performance expected in the base case (Section 6.1) and the factors that produce the TSPA-VA uncertainty results (Section 6.2).

6.1 Base Case Expected Repository Performance

The deterministic results for the TSPA-VA base case are responsive to the Congressional mandate for assessment of "*...the probable behavior of the repository in the Yucca Mountain geological setting....*" These results were a forecast of the dose rate to the average individual located 20 km from the repository, for time periods up to one million years. Graphs showing forecasts of peak doses throughout the million-year time period were produced, and specific dose-rate values were identified and discussed for time periods of 10,000, 100,000 and one million years.

DOE described the results for the deterministic evaluation in which values for all uncertain parameters were set at their expected values as follows (Volume 3 of the VA report, page 4-21):

> *1. Within the first 10,000 years, the only radionuclides to reach the biosphere are the nonsorbing radionuclides with high inventories, technetium-99 and iodine-129, and the total peak dose rate is about 0.04 mrem/year.*

2. Within the first 100,000 years, the weakly sorbing radionuclide neptunium-237 begins to dominate doses in the biosphere at about 50,000 years, with the total dose rate reaching about 5 mrem/year.

3. Within the first million years, neptunium continues to be the major contributor to peak dose rate, which reaches a maximum of about 300 mrem/year at about 300,000 years after closure of the repository, just following the first climatic superpluvial period. The radionuclide plutonium- 242 is also important during the one million-year time frame and has two peaks, at about 320,000 and 720,000 years, closely following the two superpluvial periods. There are regularly spaced spikes in all the dose rate curves (more pronounced for nonsorbing radionuclides such as Tc-99 and I-129) corresponding to the assumed climate model for the expected value base-case simulation...these spikes are a result of assumed abrupt changes in water table elevation and seepage through the packages.

As shown in Figure 6-1, doses to the receptor 20 km from the repository, as a result of the mobile Tc-99 and I-129 radionuclides, first occur about 3,500 years after disposal. This scenario results from the assumption that a single juvenile waste-package failure occurs at 1,000 years; the "blip" in the curve at about 5,500 years is the result of the change of climate conditions from dry to long-term average at 5,000 years, which causes a major rise in the water table. During the 10,000-year period, 17 additional packages are modeled to fail at various times, beginning at about 4,200 years. These failures contribute to the dose at 10,000 years in accord with the TSPA-VA model assumptions concerning package failure times and conditions.

Dose rate histories for times up to 100,000 years are shown in Figure 6-2. Tc-99 continues to dominate the dose rate up to about 50,000 years, after which the Np-237 dominates the dose rate out to 100,000 years. The Np-237 does not begin to appear at the dose location until after about 30,000 years, because its release from the waste form is solubility limited and it exhibits some sorption on the rock surfaces along the transport pathway. The Pu-239 does not begin to appear at the dose location until more than 80,000 years have elapsed because it is more strongly sorbed than the Np-237. A small fraction of the Pu-239 is assumed, however, to be attached to colloids that are not sorbed onto the rock surfaces.

As for the 10,000-year results, the dose rate forecasts for periods to 100,000 years are dominated by climate change assumptions and waste package failure history. The jagged appearance of the Tc-99 curve is the result of individual package failures; each small peak corresponds to a failure. This illustrates one of the key features of the TSPA-VA modeling scheme: because features such

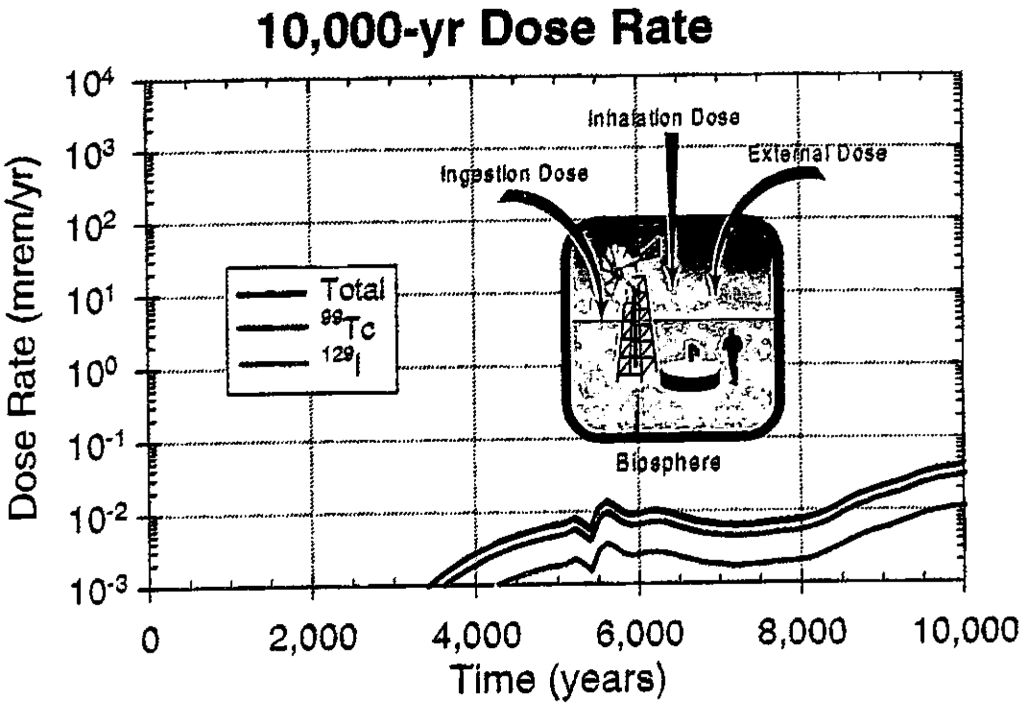

Figure 6-1. Expected-Value Dose Rates to 10,000 Years for the TSPA-VA Base Case (Source: DOE 1998a, Volume 3)

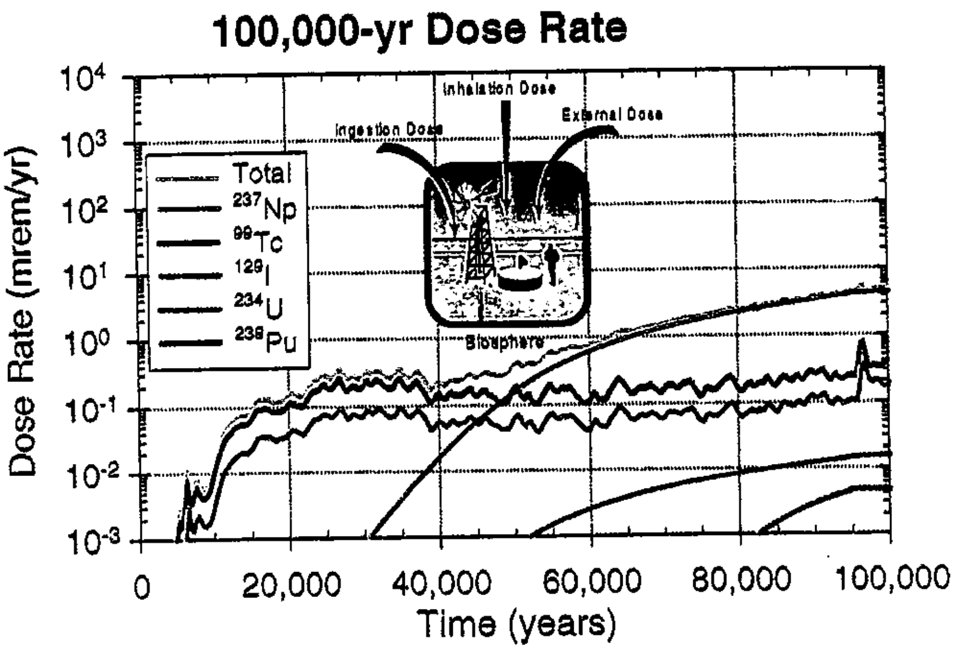

Figure 6-2. Expected-Value Dose Rates to 100,000 Years for the TSPA-VA Base Case (Source: DOE 1998a, Volume 3)

as slow drip entry to the package interiors and in-package dilution, which provide capacitance-type phenomena along the transport path, were not included in the models, the nonsorbing species such as Tc-99 directly track release behavior, and concentrations are simply attenuated by dilution along the pathway. The sorbing and solubility-limited species, such as Np-237 and Pu-239, exhibit capacitance-type behavior because of these properties, but the effects would have been more exaggerated if factors such as in-package dilution had been included in the TSPA models.

As shown in Figure 6-3, Np-237 continues to dominate the dose rate from 100,000 years all the way to the end of the million-year dose evaluation period. At about 300,000 years, Pu-242 becomes the second most important contributor to dose and remains in this role, at a level about a factor of ten less than that of the Np-237, to the end of the dose evaluation period. The contribution of other radionuclides to dose during the long-range time frame is insignificant.

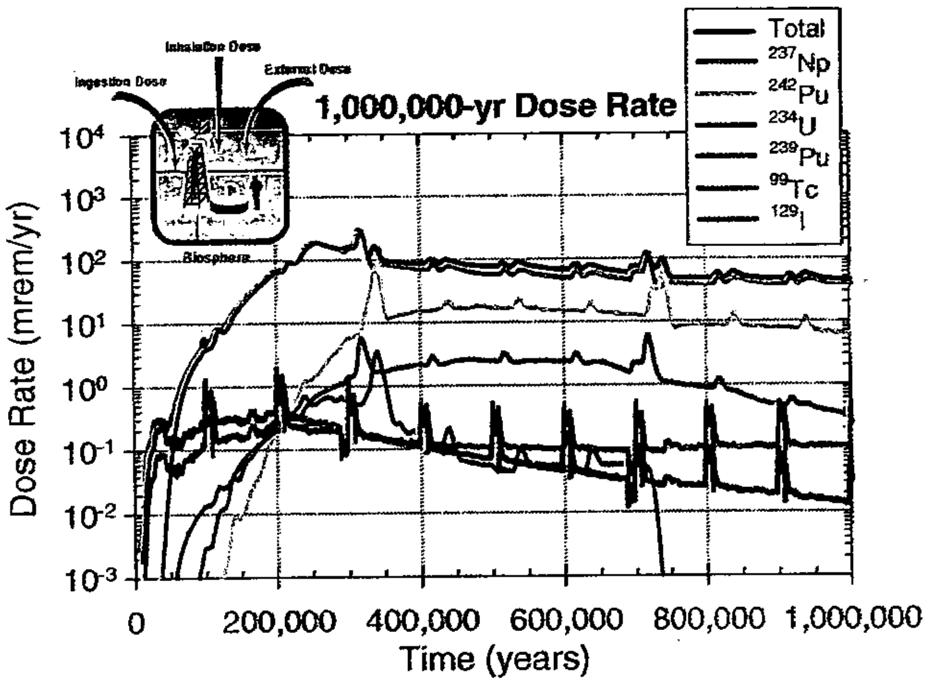

Figure 6-3. Expected-Value Does Rates to One Million Years for the TSPA-VA Base Case (Source: DOE 1998a, Volume 3)

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The dose rate after about 300,000 years is seen in Figure 6-3 to be essentially constant. This is because, in the TSPA-VA modeling scheme, the repository as a source term for radionuclides released to the environment goes into essentially steady state. All of the packages that are modeled to fail have failed, the seepage fluxes into the repository and into the packages have become virtually the same and constant, and the rate of change in exposure of waste form has become constant.

The dominant effect of waste package failure history and climate conditions on dose rates continues to the end of the million-year dose evaluation period. At about 200,000 years, cladding degradation begins to contribute to the exposed waste form area, and at times greater than about 700,000 years, waste packages that are never dripped on, which total about 55% of the package inventory, begin to fail as a result of low corrosion rates in a non-wetted condition over a very long time frame.

In summary, the base case TSPA results for the VA repository show that the performance of the highly complex and multi-element system is strongly dominated by a very few factors. In brief:

- Performance throughout the million-year period is dominated by assumptions concerning waste package failure history and climate. The effect of these factors on predicted doses is primarily a consequence of the assumptions concerning juvenile failure of waste packages, and the patterns and characteristics of climate change.

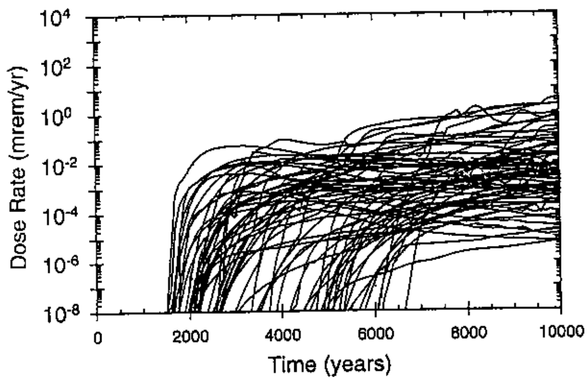
- Three nuclides dominate the forecast doses: Tc-99 and I-129 in the shorter time frames and Np-237 in the longer time frames. Note that the dose levels associated with the Np-237 are much higher than those associated with the technetium and the iodine, in large measure because the health consequences of a unit quantity of Np-237 are much greater than those for the technetium and iodine.

- The fact that the dose results clearly reflect the occurrence of climate changes and individual package failures shows that the TSPA-VA modeling system is fundamentally simple. Factors in performance that would serve to smooth and smear the consequences of phenomena that change system conditions were omitted from the models.

In addition to these observations based on the predictions of doses obtained, it can also be observed that the levels of dose forecast, e.g., 0.04 mrem/yr at 10,000 years, are the result of DOE's pattern of selecting features of models, such as omission of in-package dilution, and in assigning values to some key performance parameters, such as the area of waste form exposed when the cladding on a fuel rod is breached. This consideration is discussed in Section 7 below.

6.2 Uncertainty in the TSPA-VA Results

The Monte Carlo type of analyses that were done to assess the uncertainty in the TSPA-VA deterministic base-case results showed an uncertainty range spanning about four to five orders of magnitude throughout the million-year period, as shown in Figure 6-4. These results were obtained, for a given computer run, by using statistical methods to select values from the distributions for the uncertain parameters used in the TSPA-VA models. For each of the three time frames one hundred such runs were done, and a few 1,000-run studies were done to demonstrate that the uncertainty ranges found for the 100-run studies were representative.



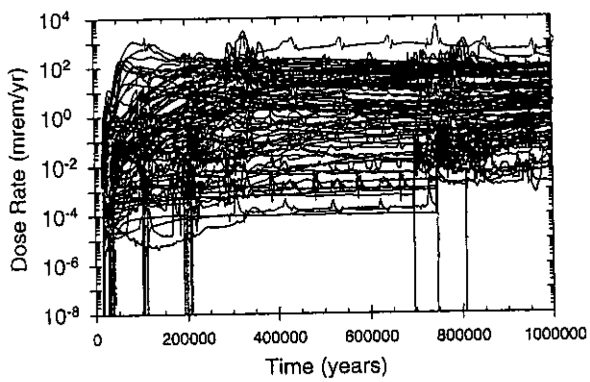


Figure 6-4. Uncertainty Evaluation Results: Does-Rate Time Histories for the 10,000-Year and One Million Year Periods (Source: DOE 1998a, Volume 3)

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The large uncertainty range, i.e., spanning four to five orders of magnitude, is in part due to the many uncertain parameters in the TSPA-VA computer codes. The RIP code alone, for example, contains 177 uncertain parameters, and there are many more in the codes that have inputs to RIP. Another possible cause of the wide uncertainty range is that many of the uncertain parameters have wide uncertainty ranges, either as a result of the fact that the actual value of the parameter is poorly known, or because the parameter is inherently highly variable. It would be difficult, if not impossible, to sort out the sources and principal causes of the uncertainty range.

The uncertainty range for the TSPA-VA results is a consequence of the specific way uncertainty was used in assigning numerical value distributions to parameters in the TSPA-VA models and codes. Another potential source of uncertainty, not reflected in the results of the TSPA-VA studies, is the possibility that some of the models used in the codes may not be correct, e.g., because of a sparse data base, or, as in the case of modeling of the near-field geochemical environment, because coupled phenomena were uncoupled for modeling purposes.

In evaluating the status of knowledge and uncertainty as a prelude to selecting further work to improve the TSPA methodology for a license application (Volume 4 of DOE 1998a), DOE often noted that the models used in the TSPA-VA might not adequately capture the full range of possibilities. If this is indeed the case, and the uncertainty in parameters or models has to be expanded in order to embrace the full range of possibilities (as opposed to simply revising the model in response to better information), the uncertainty ranges for future TSPAs might actually be wider.

7.0 FINDINGS CONCERNING THE TSPA-VA RESULTS AND UNCERTAINTIES

This section discusses the information presented above concerning TSPA-VA methodology, results, and uncertainties. To produce this information, the TSPA-VA was reviewed and analyzed to gain insight into factors such as how and why DOE used conservatism in the TSPA-VA evaluations, what alternative strategies might be used to produce TSPA-VA results, and what the implications of a wide range of uncertainty might be.

Within the framework of the TSPA-VA methodology, the base-case results and uncertainties are affected by selections of models, uncertainty ranges for uncertain parameters, and assumptions made because the data basis for parameter valuation is not definitive. These selections can affect

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the outcome of the TSPA evaluations. For example, assumptions concerning juvenile waste package failures strongly affect forecasts of peak dose rate at 10,000 years; assumption of a wide uncertainty range for uncertain parameters with a limited data base may affect the width of the uncertainty range associated with the base-case results.

7.1 Key DOE Selections

DOE's key selections of models, assumptions, and data-utilization methods for each of the principal TSPA-VA performance factors are listed below.

Climate: The TSPA-VA assumed that the current dry climate will persist for another 5,000 years, to be followed by a long-term-average climate with twice the current precipitation rate, and subsequently a superpluvial period with three times the current precipitation rate. Volume 4 of the VA states that some data indicate that the present climate conditions could persist for as long as 20,000 years, in which case the effect of the assumed transition to long-term average climate at 5,000 years on the 10,000-year dose rate would be removed from the TSPA-VA base-case results.

Percolation to Depth: The TSPA-VA is based on site data as much as possible, which indicates spatial variation throughout the repository footprint. Volume 4 notes that all possibilities have probably not been considered.

Seepage into Drifts: The TSPA-VA seepage model is based on the percolation model and experimental data as much as possible. The models for seepage flux and fraction of packages that are exposed to seeps show great uncertainty. Volume 4 states that the models probably do not reflect the full range of variability.

Heat and Excavation: The TSPA-VA assumes that the hydrologic properties of the rock are not affected by the thermal pulse, on the basis that any changes would be within the range of normal variability. Volume 4 indicates that DOE has low confidence that the current mountain-scale and drift-scale representations span the range of realistic possibilities.

Drips on Packages: Packages that are dripped on (derived from the seepage model) are assumed to be the width of the drift (5 m rather than 2 m) and to be entirely wetted above the midplane.

Volume 4 acknowledges that the approach is conservative but does not estimate the degree of conservatism.

Waste Package Humidity and Temperature: These characteristics of the repository can be estimated with a high degree of reliability using well-established principles and models for engineered systems. The results of these characterizations, e.g., waste package temperatures as a function of time, are the boundary conditions for thermal hydrology effects.

Waste Package Chemistry: The TSPA-VA recognizes that local chemistry conditions that can cause corrosion of a waste package are unlikely to be the same as the drift-scale conditions. Conditions are characterized on the basis of known corrosion characteristics of the waste package metals. Corrosion and chemistry conditions for the steel outer wall are based on available data. The Alloy 22 inner wall is assumed to be degraded by crevice corrosion, which proceeds at a rate about 25 times higher than the assumed general corrosion rate for this material. The effect of large quantities of concrete on local corrosion conditions is discussed in the VA, but is not a factor in the TSPA-VA analyses and results.

Juvenile Package Failures: The TSPA-VA assumes, on the basis of some historical data, that 1 to 10 packages might fail prematurely as a result of deficiencies such as manufacturing defects. One such failure at 1,000 years was assumed for the base case TSPA-VA; it increased the projected dose rate at 10,000 years by about a factor of 10 in comparison with an assumption of no juvenile failures. The penetrations of the prematurely failed package were assumed to be large patches rather than small areas associated with welds. The package vulnerable to premature failure was assumed to be among the few in the repository (about 1% of the inventory) that actually is dripped on.

Alloy 22 Corrosion: The TSPA-VA assumed that the corrosion-resistant Alloy 22 used as the inner package wall in the VA design would fail by crevice corrosion, and that the failure area would be the same as the failed steel area. Available data show that, in the absence of crevice or some other aggressive corrosion mechanism, the Alloy 22 would not be expected to be penetrated for at least 20,000 years.

Seepage Into Packages: The TSPA-VA assumed that any package that is wetted is entirely wetted, and that water enters the interior in proportion to the fraction of the wall that is open as a result of penetration by corrosion. Volume 4 of DOE 1998a notes that it is unclear whether the model captures the range of processes that might occur as water enters the package, and mentions, as an example of processes not represented, the potential for corrosion products to impede water entry.

Cladding Credit: The TSPA-VA makes three key assumptions concerning performance of spent fuel cladding as a barrier: (1) assemblies clad with stainless steel are assumed to be distributed among the packages and to fail completely and immediately when water enters the package; (2) the entire spent fuel inventory in a rod that has breached cladding is assumed to be exposed to, and contacted by, water that enters the package; and (3) 0.15% of the rods clad with Zircaloy are assumed to be breached at the time of emplacement for disposal.

Waste Form Dissolution: The TSPA-VA model for waste form dissolution and radionuclide release is based on empirical data which provide estimates of dissolution release rates for non-solubility-limited species such as technetium and iodine. The current model does not explicitly account for retardation of solubility-limited species such as neptunium in secondary mineral phases that are known to form rapidly from degradation of uranium dioxide after contact with water occurs. DOE observes that releases of neptunium, which are important contributors to potential doses at times after 10,000 years, could be significantly less than was assumed for the TSPA-VA analyses.

The solubility of Np is important to dose potential for time periods on the order of 50,000 years and beyond. The data base for Np solubility spans about seven orders of magnitude because of differing measurement conditions; three orders of magnitude were considered in the TSPA-VA. Volume 4 of the VA states that, because of uncertainty as to what conditions will prevail in the repository, the present representation may not capture the full range of possibilities. Consideration of waste-form degradation phenomena raises the possibility that the neptunium source will be self-limiting because of retention in the secondary mineral phases.

Colloids: The TSPA-VA assumed abundant sources of colloids in the repository, and, as a result, plutonium makes a significant contribution to potential doses for time periods on the order of 100,000 years and beyond. The data base for characterization of colloids is at present quite limited and is being extended.

EBS Transport of Radionuclides: The TSPA-VA models assume advective transport of radionuclides released from the waste form through the EBS to the Unsaturated Zone without dilution or delay. The TSPA-VA models omit phenomena that could significantly affect the time at which radioactivity enters the UZ and the initial radionuclide concentrations in water at the beginning of transit of the UZ, although these phenomena are considered and discussed in the Technical Basis Document, DOE 1998b. These phenomena include slow rates of water entry to the package interior to produce delayed contact with exposed waste forms, in-package dilution of radionuclide concentrations, diffusion controlled transport within the package to the exit, and dilution by uncontaminated percolation water during transit from the package exit to the beginning of the UZ transport regime.

Unsaturated Zone Flow and Transport: The TSPA-VA models for flow and transport in the UZ are based on available site data and expert opinion. Volume 4 of the VA notes that the models may be unrealistic when few packages are failed and those that are failed act as point sources for radionuclide release and transport. Highly conservative analyses were done for these conditions, with assumptions of minimal dilution and dispersion during transit from the repository to the dose-receptor location, and with assumption of no dilution during pumping. Projected dose rates under these conditions were a factor of 1,000 higher than the base case results. This scenario corresponds to fast-path transport without significant dilution in the UZ and stream tube transport with little dilution in the saturated zone.

Saturated Zone Flow and Transport: The TSPA-VA models for flow and radionuclide transport in the SZ were selected based on the recommendations of the expert elicitation panel because the data base for characterizing the flow regime is at present highly limited. A streamtube model was used for flow in the volcanic rocks and the alluvium, and net dilution factors were assumed to range from 2 to 100, with a mean value of 10.

Dilution During Pumping: The TSPA-VA analyses took no credit for dilution of radionuclide concentrations in water used by the dose receptor as a result of dilution due to mixing with uncontaminated water during pumping. Analyses by DOE and NRC have shown that such dilution could be significant, e.g., on the order of factors of 10 to 50, depending on flow regime, contaminant plume, and pumping conditions. The present data base does not, however, permit selection of conditions that would enable reliable assessment of dilution potential during pumping at Lathrop Wells, assumed in the TSPA-VA to be the location at which peak dose would be evaluated.

Biosphere Transport and Uptake: In the TSPA-VA, peak dose evaluations were based on available site-specific data, established dose conversion factors, and characterizations of the potential dose receptors.

7.2 Analysis of DOE Selections

The preceding list can be interpreted to show that DOE's selections of assumptions, etc., for the TSPA-VA fall into four categories:

- Where possible, established data and analysis methods were used to characterize performance parameters. Example: characterization of waste package humidities and temperatures.
- When a modeling approach was needed and choices could be identified, conservative choices were made. Example: assumption that waste packages that are dripped on are the full width of the drift.
- When performance factors that clearly contribute to performance could be easily identified but rationales for selecting parameter values were not readily available or defensible, the factors were not included in the TSPA-VA modeling structure. Example: processes that will operate in the EBS to dilute and delay radionuclide release were not included in the TSPA-VA models.
- When the data base was limited, expert judgment was used to estimate mean parameter values and their uncertainties. Example: use of the expert elicitation recommendations for potential dilution in the SZ.

The conservative TSPA-VA modeling assumptions and the omissions of performance factors with uncertainties from the TSPA-VA codes could have a direct effect on base-case peak dose rate evaluations. For example, the base-case peak dose at 10,000 years, 0.04 mrem/yr, was determined to result primarily from the assumption of one juvenile failure at 1,000 years and the assumption of climate change at 5,000 years. The peak dose rate value was also, however, dependent on the assumption of large patch openings in the prematurely failed package, the assumption that 1.25% of the spent fuel rods in the package are failed, and the assumption that all of the waste form in a failed fuel rod is exposed. These assumptions have a direct impact on the TSPA-VA results because the totally mobilized Tc-99 and I-129 are produced and move through the system with the water in accordance with the size of the source term.

The effect of the TSPA-VA assumptions and exclusion of some highly uncertain performance factors on the uncertainty range for the TSPA-VA results is not readily determined. The TSPA-VA document notes (page 4-64) that the RIP code alone uses 1,006 fixed parameters and 177 parameters with uncertainty distributions. The component models that feed RIP contain many more parameters that have uncertainty distributions. The uncertainty distributions for these parameters contribute in uncertain ways to the overall uncertainty in the TSPA-VA base-case results.

If, for example, parameters with uncertainty distributions are added to the TSPA models (e.g., for in-package dilution), the uncertainty range might move with the new 10,000-year peak dose result, i.e., if inclusion of in-package dilution reduces the peak dose at 10,000 years by two orders of magnitude, the top of the uncertainty range might also be reduced by two orders of magnitude. Alternatively, the uncertainty range might broaden because additional uncertain parameters have been introduced into the models, or it might be essentially insensitive to the change in the modeled conditions because there are so many uncertain parameters. The only way to see what might happen is to introduce the new features into the models and to do 100 Monte Carlo runs, as DOE did for the TSPA-VA.

The uncertainty range and its top level (i.e., the Monte Carlo run(s) that show the highest peak dose) may be highly important to licensing reviews. As noted in Section 6, the uncertainty range for the TSPA-VA evaluations spans five orders of magnitude, and the top of the range is at about 1 mrem/yr at 10,000 years. The uncertainty range found for the TSPA-VA results may, however, be representative of that which will be obtained for the TSPA for licensing reviews because of the many uncertain parameters important to performance for any repository design, and because of the inherent variability of some of the parameters.

The results discussed above suggest some strategic TSPA options, which can be characterized in terms of conservatism, potentially available to DOE within the framework of reasonable assurance:

- Use conservatism as much as necessary and appropriate. This will tend to understate the potential performance of the repository, but the methods and results will be relatively easy to defend. This appears to be the approach used to date.

- Incorporate all performance factors in the TSPA methodology, including those that are difficult to characterize reliably, and use conservatism selectively where the data base is limited, uncertainty is high, or inherent variability is large. This will produce TSPA results with better performance than the approach that emphasizes use of conservatism, although some elements of the results will be more difficult to defend. However, if the use of conservatism has been well chosen, (e.g., a minimal estimate of in-package dilution), the results could be acceptable in a framework of reasonable assurance.

- Incorporate all performance factors in the TSPA methodology and use reasonable, best-estimate values of performance factor parameters. This will produce best-estimate performance results, but they may be difficult to defend. Peer or regulatory reviews will identify sensitive issues that may require supplemental data or a more conservative approach.

All of these approaches would use the same available information base. In broad terms, the conservative approach takes a basically pessimistic view of the information base, the selectively conservative approach takes a moderate view, and the best-estimate approach takes an optimistic view. The conservative approach seeks to minimize issues for regulatory reviews, and the best-estimate approach might require that some issues be resolved as part of the regulatory reviews.

Experience to date indicates that DOE and NRC are both being highly conservative and seeking to resolve technical performance issues before formal regulatory reviews begin. The price being paid for this approach is a comprehensive and costly pre-licensing process that does not focus on identification and resolution of critical performance issues. The process is based on resolution of Key Technical Issues. In fact some issues are more key than others, and performance can realistically be expected to be much better than is currently portrayed.

7.3 Summary of Review Observations

Principal findings of the SC&A review are summarized as follows.

- At this VA stage of the process toward evaluation of the suitability of the Yucca Mountain site for disposal, there were data deficiencies which limit confidence in some of the models used in the evaluations and in some of the parameter values used in the models.

- Some portions of the VA documentation did not meet DOE's objective to be clear and comprehensive in its description of TSPA-VA methodology, assumptions, and use of information. The VA provided only limited description of the TSPA-VA computer codes and their use, and discussions of performance factors in the chapters of the Technical Basis Document were complex. Use of computer codes in the TSPA-VA is discussed in Appendix G of this report.

- DOE's selection of values for performance parameters was often based on limited data or recommendations from expert elicitations that were conducted in lieu of data. In some cases, such as waste package wall material corrosion rates (discussed in Appendix B), the base-case expected values used may not adequately represent the potential for radionuclide release and transport.

- DOE often selected features for TSPA-VA models that would produce high values for radionuclide release and transport. For example, it was assumed that the entire surface of the waste package is wetted when dripped on, that all seepage that contacts a package enters the package when the wall is penetrated, and that all of the waste form is exposed in a fuel rod with breached cladding.

- Some performance factors that could contribute to repository system performance, such as in-package dilution, were omitted from the TSPA-VA codes because the basis for characterizing performance parameter values was uncertain.

- The natural barrier system was assumed to make no contribution to repository system base-case performance except for dilution of radionuclide concentrations by a factor of 10 during transit of the saturated zone. The burden for repository system performance was therefore placed on engineered features of the system, i.e., waste package wall corrosion resistance and cladding integrity. Contributions of the natural barrier system to performance are discussed in detail in Appendix A; contributions of the waste package to performance are discussed in Appendix B.

- DOE's selections of corrosion rate values for the waste package Corrosion Allowance Material (A516 carbon steel) may not adequately represent the corrosion rate potential because they do not account for the effects of drip velocity and formation of salts and chlorides. Similarly, the corrosion rates for the Corrosion Resistant Material, Alloy 22, may not adequately account for adverse crevice corrosion conditions. Corrosion rates are discussed in Appendix B.

- The VA waste package design is not an effective defense-in-depth design. Design options such as use of drip shields that were considered in the VA but not used in the TSPA-VA design have potential to significantly improve repository system performance.

- The TSPA-VA evaluations took credit for performance of cladding as an engineered barrier, but made assumptions that would tend to produce high values for release of radionuclides from the waste form. Such assumptions are concerned with the number of spent fuel rods with breached cladding, the exposed waste form area for each rod with breached cladding, and release of radionuclides with limited solubility, such as Np-237, from the waste form. Modeling of waste form performance is discussed in Appendix C.

- For Tc-99 and I-129 (which are highly soluble, move with the ground water, and were found to be the only species to contribute to the 10,000-year dose rate), the assumption that natural system features contribute only limited dilution in the saturated zone to performance is realistic. The assumption is conservative for long-term dose rates, i.e., for 50,000 years and beyond,which are dominated by Np-237 and Pu-242, for which some performance contributions from the natural system may be expected as a result of sorption on rock surfaces and the radionuclides' limited solubilities.

- A key feature of the models and computer codes used for the TSPA-VA analyses was uncoupling, in the models, of thermal, hydrologic, chemical and mechanical phenomena that are known to be coupled. Coupled effects may be important to performance of a repository with the temperature and heat load characteristics assumed for the TSPA-VA analyses, but the characteristics of coupling and their effects, and the effect of model uncoupling on the reliability of the TSPA-VA results, are uncertain. Coupling effects are discussed in Appendix E of this report.

- The results of the TSPA-VA evaluations also contain uncertainties associated with modeling of thermal hydrology, which is concerned with the effects of repository temperatures and heat loads on the characteristics of the rocks and hydrologic regime surrounding the emplacement drifts. At present, the data basis for this modeling is limited, and the validity of the models is uncertain. The TSPA-VA assumed that thermal hydrologic processes are short-lived and do not permanently alter the hydrologic regime. Current information is insufficient to know if this is conservative or nonconservative. Thermal hydrology is discussed in Appendix D.

- The 10,000-year base-case dose rate evaluation results, 0.04 mrem/yr, are principally dependent on assumptions concerning early failure of a waste package at 1,000 years and a climate change, which doubles the precipitation rate and causes an 80-meter rise in the water table, at 5,000 years. In the TSPA-VA models, assumptions concerning juvenile waste package failure and climate primarily affect the rate of seepage of water into the repository and the magnitude of the radionuclide source term.

- Use of conventional uncertainty characterization techniques showed that uncertainties in the base-case expected dose results span four to five orders of magnitude. This result is associated with the large number of parameters that have uncertainty ranges, either as a result of inherent, natural variability or as a result of current data uncertainties, including those resulting from lack of data.

- Overall, there is great "uncertainty in the uncertainty" associated with the TSPA-VA results. Uncertainty is present because of the many performance parameters that are genuinely variable and uncertain; because of uncertainty ranges assigned to parameters with limited data bases; and because of uncertainty ranges assigned to parameters that cannot have an experimental data basis, such as the number of juvenile package failures and future climate conditions. Uncertainty which cannot be explicitly characterized also is present in the TSPA-VA results because of uncertainty that the models used are appropriate and sufficient representations of actual conditions (e.g., uncertainties associated with uncoupling, in the models, of coupled phenomena). Experiments concerning the sensitivity of uncertainty to its various sources in TSPA evaluations might be done by running the computer codes with alternative models and parameter-value distributions.

- As acknowledged by DOE, the TSPA-VA methodologies and information base are not adequate to produce results suitable for licensing reviews. They are, however, significant improvements over previous TSPA evaluations, and they are close to the status required for licensing reviews. Improvements needed for licensing would include revision or refinement of model details, revision of parameter values as a result of data additions, and improvement of the quality assurance basis for models, computer codes, and data. The results of TSPA evaluations for licensing reviews will, as demonstrated by the TSPA-VA results, depend strongly on the repository design features (e.g., waste package design and thermal loading) selected for licensing.

8.0 REFERENCES

DOE 1998a U.S. Department of Energy, Viability Assessment of a Repository at Yucca Mountain, DOE/RW-0508, December 1998.

DOE 1998b CRWMS M&O Contractor, Total System Performance Assessment - Viability Assessment (TSPA-VA) Analyses Technical Basis Document, B00000000-01717-4301-00001 Rev 01, November 13, 1998.

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APPENDIX A

MODELING OF FLOW AND RADIONUCLIDE TRANSPORT IN THE UNSATURATED AND SATURATED ZONES IN THE TSPA-VA

MODELING OF FLOW AND RADIONUCLIDE TRANSPORT IN THE UNSATURATED AND SATURATED ZONES IN THE TSPA-VA

1.0 GROUNDWATER FLOW AND CONTAMINANT TRANSPORT FOR A REPOSITORY AT YUCCA MOUNTAIN

Because ground water is anticipated to be the principal means by which radionuclides might be released from a repository and transported to the environment, characterization of the ground-water regime has been part of the Yucca Mountain site characterization program since it began. As a result, there is a long, comprehensive, and evolutionary history of activity to identify and resolve issues concerning the ground water regime and its contributions to repository system performance.

Key Technical Issues (KTIs) guide the program activities related to the ground water regime. The Nuclear Regulatory Commission staff established the KTIs as the basis for resolution of technical issues and as the basis for staff reviews of information developed by DOE. KTIs have been established for each of the principal repository system performance factors, and are addressed in Issue Resolution Status Reports (IRSRs), which are the evolving record of the Yucca Mountain program status in comparison with requirements for issue resolution.

As part of the issue resolution process, the NRC has developed Acceptance Criteria for the key issues that will ultimately need to be resolved before a repository is licensed at Yucca Mountain. These criteria are set forth in the IRSRs and are the basis for NRC assessment of whether the methods and information presented by DOE can produce results that are defensible under regulatory reviews. Therefore, and because the effort concerning the hydrologic regime is highly evolved (in contrast, DOE attempted modeling of the near field geochemical regime for the first time in the TSPA-VA), the NRC Acceptance Criteria were used as a framework for the SC&A review of this part of the TSPA-VA.

The two NRC Issue Resolution Status Reports that are most pertinent to groundwater flow and contaminant transport are entitled *Issue Resolution Status Report - Key Technical Issue: Unsaturated and Saturated Flow under Isothermal Conditions* and *Issue Resolution Status Report - Key Technical Issue: Radionuclide Transport.*

The following discussion is organized by Key Technical Issues. Under each issue, NRC's Acceptance Criteria are presented and their assessment as to whether DOE has, to date, met the criteria is also presented. Each subsection concludes with an evaluation by SC&A with respect to the potential for satisfactory resolution

2.0 NRC's ISSUE/SUBISSUE STATEMENT

NRC developed the Issue Resolution Status Reports with the primary objective of assessing all aspects of the ambient hydrogeologic regime at Yucca Mountain that have the potential to compromise the performance of the proposed repository. The secondary objective was to develop review procedures and to conduct technical investigations to assess the adequacy of DOE's characterization of key site- and regional-scale hydrogeologic processes and features that may adversely affect performance. NRC identified the following primary issues with respect to the hydrologic regime.

- Hydrologic Effects of Climate Change
- Present-Day Shallow Infiltration
- Deep Percolation (Present and Future)
- Saturated Zone Ambient Flow Conditions and Dilution Processes
- Matrix Diffusion
- Radionuclide Transport Through Porous Rock
- Radionuclide Transport Through Alluvium
- Radionuclide Transport Through Fractured Rock

The following sections discuss each of the above issues by presenting its relevance to Total System Performance Assessment (TSPA), NRC's Acceptance Criteria and resolution status, and an independent evaluation of the likelihood that DOE can meet the requirements of the Acceptance Criteria for the license application.

3.0 ISSUE RESOLUTION STATUS

3.1 Hydrologic Effects of Climate Change

For DOE to adequately demonstrate and quantify in its Total System Performance Assessment (TSPA) the effects that climate change might have on repository performance, the NRC believes that it should consider how these effects interplay with the other factors within and between key elements in the engineered and natural subsystems of the repository. Climate change and its hydrologic effects are important factors that need to be abstracted into three of the key elements of the engineered and natural subsystems: (1) spatial and temporal distribution of flow; (2) flow rate in water production zones; and (3) location and lifestyle of critical group (includes consideration of water-table rise).

See NRC 1997a for a description of the technical basis for review methods and acceptance criteria for the subissues of climate change and hydrologic effects of climate change. An important new paper on Devils Hole was published in 1997; however, at this time it has not led the NRC to change the previously developed acceptance criteria.

The NRC has previously recommended a pragmatic approach to address climate change (NRC 1997a, p. 8). Under this approach, global, enhanced greenhouse warming would be presumed to last no more than several thousand years, and about 3 ky (1 ky = 1,000 years) into the future, the climate at Yucca Mountain would resume global cooling as predicted by the Milankovitch orbital theory of climate. Pluvial conditions should be expected to dominate at least several thousand years of the next 10 ky. NRC believes that current information suggests that past climate conditions were cooler and wetter than today, about 60 to 80% of the time.

3.1.1 <u>NRC Acceptance Criteria</u>

In its Technical Review of the TSPA-VA, the NRC it will determine whether DOE has reasonably complied with the Acceptance Criteria listed below:

(1) Climate projections based primarily on paleoclimate data are acceptable for use in performance assessments of the YM site. During its review, the staff should determine whether DOE has made a reasonably complete search of paleoclimate data that are available for the YM site and region, and has satisfactorily documented the results. Staff should determine that, at a minimum, DOE has considered information contained in Forester, et al. (1996); Winograd, et al. (1992); Szabo, et al. (1994); and other reports that may become available.

(2) DOE's projections of long-term climate change are acceptable if these projected changes are consistent with evidence from the paleoclimate data. Specifically, staff should determine whether DOE has evaluated long-term climate change based on known patterns of climatic cycles during the Quaternary, especially the last 500 ky. The current analysis indicates that these cycles included roughly 100-ky cycles of glacial/interglacial climates,

with interglacials lasting about 20 ky. Current information also suggests that past climate conditions were cooler and wetter than today, about 60 to 80% of the time.

(3) The NRC will not require climate modeling to estimate the range of future climates. If DOE uses numerical climate models, staff will determine whether such models were calibrated with paleoclimate data before they were used for projection of future climate, and that their use suitably simulates the historical record.

(4) Values for climatic parameters (time(s) of onset of climate change; mean annual precipitation (MAP); mean annual temperature (MAT); etc.) to be used in DOE's safety case should be adequately justified. The NRC will determine whether appropriate scientific data were used, reasonably interpreted, and appropriately synthesized into parameters such as MAP, MAT, and long-term climate variability. The current knowledge about these parameters, coupled with past climate change, will require that, as a bounding condition, a return to full pluvial climate (higher precipitation and lower temperatures) be considered for at least a part of the 10-ky period (current information does not support persistence of present-day climate for a duration of 10 ky or more). The current interpretations of paleoclimate data indicate an increase in MAP by a factor of 2 to 3 and a lowering of MAT of 5-10°C (9-18°F) during the pluvial climate episodes.

(5) If DOE uses expert elicitation to arrive at values of climate parameters, NRC will determine whether DOE followed the guidance in the Branch Technical Position on Expert Elicitation (NRC, 1996a).

(6) Bounding values of climate-induced effects (for example water-table rise) based primarily on paleoclimate data will be acceptable. NRC should determine whether DOE has made a reasonably complete search of paleoclimate data pertinent to water-table rise and other effects (for example, changes in precipitation and geochemistry) of climate change that are available for the YM site and region, and has satisfactorily documented the results. In evaluating DOE's analyses, staff should determine whether, at a minimum, DOE has fully considered information contained in Paces, et al. (1996a), Szabo, et al. (1994), Forester, et al. (1996), and other reports that may become available.

(7) It will be acceptable for DOE to use regional and sub-regional models for the saturated zone to predict climate-induced consequences if these models are calibrated with the paleohydrology data. Staff should determine whether DOE's models of the consequences of climate change are consistent with evidence from the extensive paleoclimate data base. Specifically, climate-induced water-table rise is expected to occur in response to elevated precipitation during future pluvial climate episodes, and the staff should determine whether DOE's estimates of climate-induced, water-table rise are consistent with the paleoclimate data. The current estimate of water-table rise during the late Pleistocene is 120 m (394 ft). NRC should determine whether DOE's assumptions about climate-

induced, water-table rise over 10 ky, if different from 120 m (394 ft), are adequately justified.

(8) Based on judgment and analysis, staff will determine whether DOE has adequately incorporated future climate changes and associated effects in its performance assessments. Current information does not support an assumption that present-day climate will persist unchanged for 10 ky or more. The staff should keep in mind that the consequences of climate change may be coupled to other events and processes and therefore the projections of water-table rise that are used in total system performance may be different from those based solely on climate change.

(9) NRC will determine whether the collection, documentation, and development of data, models, and computer codes have been performed under acceptable QA procedures. If not subject to an acceptable QA procedure, data, models, and codes must have been appropriately qualified.

3.1.2 Status of Issue Resolution at the NRC Staff Level

In Attachment E of the Issue Resolution Status Report for Unsaturated and Saturated Flow, the NRC presents its current concerns related to the potential influence of climate change on groundwater flow. The text indicates that the NRC has identified no open items solely related to future climate change and associated hydrologic effects.

3.1.3 SC&A Evaluation of Whether DOE Can Meet NRC's Acceptance Criteria

DOE presents its current approach to evaluating climate-induced changes to the hydrologic regime in Sections 3.1.2.1 and 3.7.2.3 of the TSPA-VA, for the unsaturated and saturated zones respectively.

The potential effects of climate change on the hydrologic regime are evaluated in the TSPA-VA by assuming three states: dry or present-day climate; long-term average climate; which is about twice the dry-climate precipitation; and superpluvial climate which is about three times the dry-climate precipitation. The time frames over which these precipitation rates are applied are statistically sampled.

In the saturated zone, the DOE incorporated the effects of climate change on radionuclide transport by assuming instantaneous change from one steady-state flow condition to another steady-state flow condition. Changes in climate were assumed to affect the magnitude of the groundwater flux through the saturated zone but to have a negligible impact on flowpaths.

This approach is far more simplistic than the NRC Acceptance Criteria would suggest is appropriate. Furthermore, the DOE provides very little rationale for how it has determined the time frames or the specified climatic cycles and associated precipitation rates. The NRC makes it clear that the DOE will need to evaluate the temporal and spatial effects caused by climate change on groundwater flow. DOE may argue, however, that since the critical group is always located on the centerline of the plume, the effect of climate change on groundwater paths will have little impact on dose to the critical group.

The NRC expects that the climate change modeling will include both regional and subregional models that have been calibrated with the paleohydrology data, and NRC will make an evaluation of whether DOE's models are consistent with evidence from the paleoclimate data base. Although DOE's approach to modeling climate change presented in the TSPA does not appear to meet NRC's Acceptance Criteria, it is likely that DOE will be able to rectify the apparent shortcomings for the TSPA-LA.

3.2 Present-Day Shallow Infiltration

NRC believes that present-day shallow infiltration is a key hydrologic factor in the isolation of high-level wastes within the proposed geologic repository at YM. Present day shallow infiltration should be reasonably understood to provide initial conditions for projecting future hydrologic changes, because the Earth's climate could change significantly during the time that wastes will remain hazardous. Climate controls the range of precipitation that, in part, controls the rates of infiltration, deep percolation, and groundwater flux through a geologic repository located in an unsaturated environment. Water flow through a geologic repository and its environs depends on both surface processes (precipitation, evapotranspiration, overland flow, and infiltration) and subsurface processes (deep percolation, moisture recirculation, and lateral flow). Changes in infiltration will likely induce other changes, such as regional fluctuations in the elevation of the water table. Water-table rise would reduce the thickness of the unsaturated zone barrier. Therefore, future changes in climate could alter infiltration from present-day rates and significantly influence the ability of a repository to isolate waste.

The importance of groundwater flux as the key parameter for repository performance in an unsaturated zone is well known and has been further emphasized in DOE's 1995 Total System Performance Assessment (TSPA). On page ES-30 of that report, it is stated that:

> *...in the overall TSPA analyses, an over-arching theme comes back again and again as being the driving factor impacting the predicted results. Simply stated, it is the amount of water present in the natural and engineered systems and the magnitude of aqueous flux through these systems that controls the overall predicted performance.... Therefore, information on...[this topic]...remains the key need to enhance the representativeness of future iterations of TSPA.*

Sensitivity studies clearly showed the predominance of percolation flux in estimating cumulative radionuclide releases and peak radiation doses over a 10-ky period (see DOE, 1995, pp. 10-6 and 10-7).

DOE's "Waste Containment and Isolation Strategy" (DOE, 1996, p. 5) likewise states that *"performance assessments have shown that seepage into the emplacement drifts is the most important determinant of the ability of the site to contain and isolate waste."* This conclusion was reiterated in DOE's recently published Repository Safety Strategy (DOE, 1998). The importance of infiltration as a hydrologic parameter was also recognized by the NRC in its Iterative Performance Assessment Phase 2: *"Although the flux of liquid water through the repository depends on...infiltration, hydraulic conductivity, and porosity, performance correlates most strongly to infiltration"* (NRC 1995, p. 10-4).

In Section 5.1.2 of DOE's 1998 TSPA-VA, the sensitivity to infiltration is investigated by skewing the probabilities to the higher infiltration rates currently used in the simulations. The results of this analysis showed relatively small differences in the overall peak individual dose rates largely because of other factors such as seepage and waste package corrosion uncertainties.

The NRC believes that for DOE to adequately demonstrate and quantify in its TSPA-LA the effects of present-day infiltration on repository performance, it should consider how these effects interplay with the other factors within and between key elements in the engineered and natural subsystems of the repository.

[See NRC 1997b for a description of the technical basis for review methods for the issue on present-day shallow infiltration.]

3.2.1 NRC Acceptance Criteria

In the NRC's Technical Review of the TSPA-LA, it will determine whether DOE has reasonably complied with the Acceptance Criteria listed below:

(1) NRC shall determine whether DOE has estimated shallow infiltration for use in the PA of YM using mathematical models that incorporate site-specific climatic, surface, and subsurface information. Staff will also determine whether DOE provided sufficient evidence that the mathematical models were reasonably verified with site data. These data would include measured infiltration data and indirect evidence such as geochemical and geothermal data. DOE may choose to use a vertical one-dimensional (1D) model to simulate infiltration. However, in that case, DOE should reasonably show that the fundamental effects of heterogeneities, time-varying boundary conditions, evapotranspiration, depth of soil cover, and surface-water runoff have been considered in ways that do not underestimate infiltration.

(2) NRC shall determine whether DOE has: (1) appropriately analyzed infiltration at appropriate time and space scales; and (2) has tested the abstracted model against more detailed models to assure that it produces reasonable results for shallow infiltration under conditions of interest. Recent studies by the NRC (Stothoff, et al., 1996) and the DOE (Flint, et al., 1994; Flint and Flint, 1995; Flint, et al., 1996a) suggest that shallow infiltration is relatively high in areas where rocks are covered with shallow soils or channels and relatively low in areas where soil cover is deep. In addition, infiltration takes place episodically in time, with areas having a shallow soil cover contributing more frequently.

(3) NRC shall determine whether DOE has characterized shallow infiltration in the form of either probability distributions or deterministic upper-bound values for PA, and whether DOE has provided sufficient data and analyses to justify the chosen probability distribution or bounding value. DOE's expert elicitation on unsaturated zone flow (Geomatrix, 1997) resulted in various estimates of a related parameter, the groundwater percolation flux at the depth of the proposed repository. The estimated aggregate mean flux was approximately 10 mm/yr. The panelists estimated the 95th-percentile percolation flux over a range from 10 to 50 mm/yr, with an aggregate estimate of 30 mm/yr. An independent NRC staff assessment of an upper bound for yearly shallow infiltration under present climatic conditions is about 25 mm, which is somewhat less than the aggregate 95th percentile flux estimated by the expert panel.

(4) DOE's estimates of the probability distribution or upper bound for present-day shallow infiltration need not be refined further if DOE demonstrates through TSPA and associated sensitivity analyses that such refinements will not significantly alter the estimate of total-system performance.

(5) If used, expert elicitations should have been conducted and documented using the guidance in the Branch Technical Position on Expert Elicitation (NRC, 1996), or other acceptable approaches.

(6) NRC will determine whether the collection, documentation, and development of data, models, and computer codes have been performed under acceptable QA procedures. If they were not subject to an acceptable QA procedure, the data, models, and codes must have been appropriately qualified.

3.2.2 Status of Issue Resolution at the NRC Staff Level

In Attachment F of the Issue Resolution Status Report for Unsaturated and Saturated Flow, the NRC presents its current concerns related to present day shallow infiltration. The text indicates that the NRC staff has identified no open items solely related to present-day shallow infiltration.

3.2.3 SC&A Evaluation of Whether DOE Meet NRC's Acceptance Criteria

The DOE describes its approach to implementing present-day infiltration into the performance assessment in Section 3.1 of the 1998 TSPA. The approach tends to be very sophisticated and utilizes three dimensional flow and transport models. The results from the detailed modeling were subsequently used to develop a more simplified or abstracted model for the performance assessment calculations.

Although the DOE appears to generally meet the NRC's Acceptance Criteria, the Department will have to either perform additional work or provide additional documentation in some areas. These areas are related to the testing and comparison of the abstracted model(s) with the more detailed numerical models. It does not appear, however, that DOE will encounter any serious problems in ultimately meeting NRC's Acceptance Criteria with respect to present-day shallow infiltration in a License Application.

3.3 Deep Percolation (Present and Future)

The importance of groundwater flux as the key parameter for waste isolation at YM is well known and has been further emphasized by the DOE report on TSPA (TRW Environmental Safety Systems, Inc., 1995).

Deep percolation is related to two of the key elements of the engineered and natural subsystems: (1) quantity and chemistry of water contacting waste packages and waste forms; and (2) spatial and temporal distribution of flow.

The NRC's technical review of DOE's treatment of deep percolation will entail an evaluation of the completeness and applicability of the data and evaluations presented by DOE. NRC expects that DOE will summarize or document the results of all significant related studies conducted in the YM vicinity.

3.3.1 NRC Acceptance Criteria and Resolution Status

In the NRC's Technical Review of the TSPA-LA it will determine whether DOE has reasonably complied with the Acceptance Criteria listed below. The results of NRC's most recent compliance determinations are also presented.

(1) It will be acceptable for DOE to estimate present-day deep percolation (1) by using a reasonable upper bound based on available data; or (2) through a demonstration in TSPA and associated sensitivity analyses that further refinement of the estimate will not significantly alter the estimate of total-system performance. In the latter case, the NRC will conduct an independent analysis to judge the appropriateness of the estimate. In the VA analysis, it will be acceptable to use the aggregate distribution for areally averaged percolation flux estimated through the expert elicitation (i.e., Geomatrix, 1997). DOE's current infiltration map (e.g., Flint, et al., 1996a) may be used to account for spatial variations in percolation.

NRC Analysis: The base-case percolation flux as described by Andrews (1998) appears acceptable at this time because it is similar to that estimated through expert elicitation (Geomatrix, 1997). If DOE uses this base-case flux, this acceptance criterion will be met.

Status and NRC specified path to resolution: Open, pending review of DOE's VA.

(2) DOE's estimate of future percolation will be acceptable if it provides a reasonable basis for assumed long-term average net infiltration and percolation flux. It will be acceptable to apply spatial- and temporal-average values of deep percolation through the use of an abstracted deep percolation model in PA. In arriving at spatial- and temporal-average values, variability must be appropriately considered; model parameters must be averaged over appropriate time and space scales; and the abstracted model must be tested against more detailed models and field observations to assure that it produces reasonably

conservative dose estimates. The current understanding is that a vertical one-dimensional (1 D) model, capable of considering heterogeneities and time-varying boundary conditions at the ground surface, may be sufficient for such calculations above the repository, while a vertically oriented, two dimensional (2D) model or three dimensional (3D) model may be necessary below the repository.

NRC Analysis: DOE currently assumes that long-term average precipitation at YM will be twice as high as present conditions and long-term average percolation will be six times greater (Andrews 1998). The assumption about long-term average precipitation at YM is reasonably consistent with that recommended in Attachment E (NRC, 1997a). It is not yet clear whether a six-fold increase in long-term average percolation is reasonable. The staff will make that determination after review of DOE submittals.

The NRC staff considers that the LBNL 3D site-scale model may be too coarse to provide more than a general indication of subsurface processes at YM, but notes that significant model refinement may be computationally infeasible. Despite these reservations, NRC staff endorses the LBNL philosophy of using all available sources of information to calibrate the site-scale model, and agrees that, for many purposes, homogeneous effective properties for each layer obtained through inverse modeling may be adequate.

The NRC staff supports the use of the DKM (i.e., dual permeability) approach for site-scale flow modeling as long as DOE demonstrates that the results bound the effect of episodic infiltration and percolation pulses.

The NRC staff considers that approaches used by DOE to estimate parameters for flow and transport simulations generally use sound methods, particularly in the most recent work. The NRC staff notes, however, that subgrid heterogeneity is not explicitly and transparently addressed in the approaches and cautions that failure to consider subgrid heterogeneity may lead to qualitatively incorrect results. Small-scale modeling of heterogeneous zones is one approach that may be used to support use of uniform properties in hydrostratigraphic units of the site-scale UZ flow model.

The staff has reasons to believe that recharge and percolation in the YM region may increase in the next few decades due to replacement of native shrubs by invading brome grasses. The effect will likely be to replace the zero distributed recharge occurring in the alluvial basins with, perhaps, 1 to 10 mm/yr under current conditions. Recharge in upland areas like YM may also increase. The effect may be significantly greater during pluvial periods. This point is based on infiltration simulations, and on observations of increased streamflows where invasions of Bromus species have occurred in Nevada (personal communication, R. Fedors, CNWRA).

Status and NRC Specified Path to Resolution: Open, pending review of DOE's VA.

(3) It will be acceptable for DOE to conservatively assume that the fraction of deep percolation that intercepts disposal drifts also drips onto waste packages. Technical bases should be provided for deep percolation that is considered to bypass emplacement drifts. These technical bases should use field observations, experimental data from the ESF facility, calculations based on mass balance, tracer studies, and data from natural analog sites. Likely changes in percolation rates and patterns due to climate change should also be considered. Also, the abstracted model used in PA should be tested against more detailed models and field observations to assure that it produces reasonably conservative dose estimates. It is known that the amount of deep percolation into the waste emplacement drifts is sensitive to fast flow in fracture zones. Such flow paths need to be considered in DOE's calculations.

NRC Analysis: DOE is developing an approach for estimating seepage into drifts. The current DOE approach for drift-scale modeling for isothermal flow is apparently to represent the fracture system as an equivalent continuum with or without incorporating the matrix continuum (Birkholzer, 1998; Nitao, 1997). However, it is not clear that the fracture system can be represented as a continuum at the scale of an emplacement drift based on the average fracture spacings in the repository horizons and the grid size in the numerical model. Alternative approaches will be needed to support estimates of seepage.

Although direct measurement of percolation flux at spatial and temporal scales relevant to modeling at YM is difficult to accomplish, the NRC staff believes that efforts should continue to identify pathways and measure percolation in the field at YM. A number of field tests designed to investigate percolation and seepage rates are planned or currently in progress, notably the alcove and niche infiltration tests and testing planned for the east-west drift in the Topopah Springs welded tuff formation (Wang, et al., 1998). The direct measurement of percolation flux is encouraged, and DOE should consider, to the extent practicable, that the proposed east-west drift be allowed to equilibrate with ambient conditions by closing down the tunnel for a period of time. The east-west drift has a significant lateral extent for observing seepage and dripping into the tunnel under ambient conditions, and will cross beneath what are expected to be areas of relatively high infiltration.

Besides providing independent estimates of deep percolation rates, the NRC staff will review whether the data used in the methods described in the following sections were extensively incorporated, either directly or as constraints, into the calibration process for the LBNL site-scale numerical model of the flow field (Bodvarsson, et al., 1997a).

NRC believes that another possible way that DOE can demonstrate a reasonable approach is to assume that the fraction of percolating water that contacts waste packages is at least as great as the amount that intercepts disposal drifts. This means that most deep percolation will bypass waste packages because the disposal drifts occupy a relatively small areal percentage of the repository. This approach is probably reasonable and conservative given the tendency of underground openings to divert UZ flow laterally. It may not be reasonable to assume that all packages will receive equal amounts of dripping. Many may receive little or no dripping, while others could experience greater than average dripping over long time periods, especially during pluvial climate episodes.

Status and NRC Specified Path to Resolution: Open, pending review of DOE's VA and key supporting documents like Bodvarsson, et al., 1997a.

(4) It will be acceptable for DOE to conservatively assume that all deep percolation below the repository level bypasses the bulk of the units of the CHn formation, either by lateral movement above the units or through vertical flow through fractures and faults. Technical bases should be developed for any deep percolation considered to flow vertically through the matrix of the nonwelded zone. Such technical bases should consider spatial and temporal variability and the scales at which model parameters have been averaged. Also, the abstracted model should be tested against more detailed models and field observations to assure that it produces reasonably conservative dose estimates.

NRC Analysis: The current understanding is that flow will occur predominantly vertically as matrix flow through the nonwelded vitric zones, including those that are slightly altered. Water will tend to perch upon highly zeolitized horizons and move laterally until vertical structures are encountered. Flow through fractures and fault systems will also occur. The NRC staff believes that the heterogeneity of the hydraulic properties and the characteristics of the fractures cross-cutting the units of the CHn are both poorly known. The field-scale UZ transport test at Busted Butte will significantly improve the conceptual model of flow through the CHn, and it will also contribute significant data for characterizing hydraulic properties, thus reducing uncertainty in flow rates below the repository.

DOE is continuing to work on flow below the repository, with one objective being to estimate how much bypass flux is reasonable.

Status and NRC Specified Path to Resolution: Open, pending review of DOE's VA and reports on results from the Busted Butte hydrologic test facility.

(5) If used, DOE's expert elicitations should have been conducted and documented using the guidance in the Branch Technical Position on Expert Elicitation (NRC, 1996), or other acceptable approaches.

NRC Analysis: The expert elicitation on DOE's unsaturated flow model (i.e., Geomatrix, 1997) was conducted and documented in an acceptable way.

Status and NRC specified path to resolution: Closed. The staff has no further questions at this time.

(6) NRC will determine whether the collection, documentation, and development of data, models, and computer codes have been performed under acceptable QA procedures. If not subject to an acceptable QA procedure, the data, models, and codes must have been appropriately qualified.

NRC Analysis: To be determined (TBD).

Status and NRC specified path to resolution: TBD.

3.3.2 Summary of Deep Percolation Topics That NRC Believes Warrant Further Analysis

Significant variability of flow and transport pathways and travel times is expected to occur at YM due to the natural heterogeneity, stratification, alteration, fracturing, and other characteristics of the site. The extent to which such heterogeneities of the flow system should be incorporated into the DOE site-scale UZ flow model depends on their importance for estimating seepage into the repository and flow below the repository. Conceptualizations of flow in the UZ at YM have ranged from single-continuum models, to equivalent continuum models, to dual- and multiple-continuum models, to discrete-fracture models, as the importance of particular components of the flow system was examined. Given the matrix permeability values (Flint, 1997) and assuming a unit hydraulic gradient, groundwater flowing only in the matrix would move sufficiently slowly that it would take many tens of thousands of years for shallow infiltration to go through the repository horizon and arrive at the SZ. In contrast, both geochemical evidence and transient-flow modeling have suggested that a significant amount of groundwater flux occurs in the fracture system, and that these fluxes can travel at much faster rates than in the matrix. Fluxes in the fracture systems may move sufficiently fast that some component of shallow infiltration reaches the water table in tens to hundreds of years. Differing conceptualizations of the link between the matrix and fracture systems and flow processes in the fractures cause important differences between alternative conceptual models. The differences in the conceptualizations can have a strong impact on PA modeling and, as such, are the focus of the discussion in this section.

The development of both the repository-scale and drift-scale conceptual models at YM may be partitioned into:

(1) Percolation processes above the repository, which affect the spatial and temporal distribution of water moving through the repository horizon

(2) Percolation processes at the drift scale, which affect the release of radionuclides from the repository

(3) Percolation processes below the repository, which affect the transport of radionuclides from the repository to the SZ

An assessment of current understanding of these three parts of the conceptual model is summarized below for flow above, at, and below the repository.

3.3.3 SC&A Evaluation of Whether DOE Can Meet NRC's Acceptance Criteria

The DOE presents its discussion of deep percolation in Sections 3.1 and 4.1.2 of the 1998 TSPA-VA. The NRCs greatest concern about DOE's treatment of deep percolation is the means by which fracture-matrix interactions have been characterized and modeled. The DOE, however, for the TSPA-VA, has used a dual permeability approach which NRC has indicated is acceptable. Therefore, it appears that the NRCs only remaining concerns will be associated with the defensibility of the parameter values used in the model. DOE has performed considerable work in this area and should be able to satisfy NRC's Acceptance Criteria (Bodvarsson et al., 1997, Chapter 6).

3.4 Saturated Zone Ambient Flow Conditions and Dilution Processes

This issue is important to repository performance because it constitutes an important potential pathway for radionuclide transport from the repository to the environment and receptor locations. Saturated zone characteristics will influence how future societies may use groundwater resources in the YM region. The SZ also contributes to repository performance through: (1) magnitude and direction of groundwater flow; (2) geochemical retardation; and (3) dilution of radionuclides. The time of arrival and the concentration of radionuclides at the receptor locations are based on the average groundwater fluxes and velocities and the geochemical conditions encountered along the flow paths. Longer residence times will provide opportunity for radioactive decay, and the groundwater pathways will affect transport due to retardation and adsorption.

The concentration of radionuclides at the receptor locations is also affected by the dilution processes during transport (dispersion and groundwater intrabasin mixing) and pumping. The importance of dilution of radionuclides in the groundwater is a central issue for dose reduction in the performance assessment (PA). The TSPA-VA identifies dilution in the SZ below the repository as one of the five major system attributes most important for PA. The exact nature of the standards to be set by the U.S. Environmental Protection Agency for the YM site has not been determined.

The Repository Safety Strategy (DOE, 1998, p. 13) notes:

> *Significant flow must occur in the saturated zone in order for the radionuclide-bearing flux that percolates to the water table to be diluted. The magnitude of mixing and dispersion also must be established because certain conditions have been noted to lead to persistence of contaminant plumes...However, even persistent contaminant plumes may themselves be subject to significant dilution when mixed with other water in a producing well.*

Ambient flow conditions in the saturated zone are related to three of the key elements of the engineered and natural subsystems: (1) flow rates in water-production zones; (2) dilution of radionuclides in groundwater (dispersion and well pumping); and (3) location and lifestyle of the critical group.

3.4.1 NRC Acceptance Criteria and Resolution Status

In the NRC's Technical Review of a TSPA-LA, it will determine whether DOE has reasonably complied with the Acceptance Criteria listed below. The results of NRC's most recent compliance determinations are also presented.

(1) Staff shall determine whether DOE considered conceptual flow and data uncertainties. Uncertainties due to sparse data in some areas or low confidence in the data interpretations (e.g., see discussions on p. 51-60 of Luckey, et al., 1996; also Czarnecki, et al., 1997, p. 96-1 05) should have been considered by analyzing reasonable conceptual flow alternatives supported by site data, or by demonstrating through sensitivity studies that the uncertainties have little impact on repository performance.

NRC Analysis: The reference Luckey, et al. (1996) gives an excellent description of various conceptual models of site-scale hydrology as they were known at that time. The staff will exercise professional judgment in determining whether DOE has reasonably treated the conceptual and data uncertainties in performance assessments or has shown that they will not adversely impact performance.

Status and NRC Specified Path to Resolution: Open, pending review of DOE's VA.

(2) Staff shall determine whether, based on site data, DOE has reasonably delineated approximate flow paths from beneath the repository to potential receptor locations. Flow paths should consider: (i) aquifers (volcanic, alluvium, and carbonate) and continuity of flow regimes; (ii) flow domains (matrix and fracture); (iii) flow directions; (iv) flow velocities (approximate Darcy fluxes and average linear velocities); and (v) vertical hydraulic gradients, including the potential flow direction between the Paleozoic carbonate aquifer and the volcanic aquifers. Hydraulic and tracer testing along paths to potential receptor locations should be conducted on a scale large enough to include a statistically representative elementary volume in alluvium and in the fracture network in tuffs. Enough tests should be conducted to reasonably reduce the uncertainty in hydraulic and transport properties of the units downgradient from the proposed repository, including approximate delineation of the southerly zone where the water table changes from tuffs to alluvium. These values, along with existing data such as that from the C-wells complex (e.g., Geldon, et al., 1997), should be used in groundwater flux calculations and mathematical models.

NRC Analysis: The lack of hydrologic data for alluvium is a data gap in DOE's site characterization of saturated zone hydrology. Reasonable determinations of heads, transmissivity, hydraulic conductivity, effective porosity, and dispersion coefficients should be emphasized. The hydraulic and geochemical characteristics of the likely flowpath that exists south of well JF-3 have not been evaluated. It is unknown at which locations the water table makes a transition from fractured tuff to overlying alluvium. The saturated thicknesses, hydraulic properties, and geochemical properties of alluvium have not been determined for the region that lies between well JF-3 and the Amargosa Desert. DOE's cooperative well drilling program with Nye County, Nevada, could accomplish this if the wells are sited and tested to characterize the hydrology along likely flow paths in a timely manner.

The staff believes that the three-phase SZ testing strategy described in Reimus, et al. (1998) could, if implemented, significantly improve understanding of the hydrogeologic system. New wells may be needed, but possible locations for such testing using existing wells would include (1) J-12, JF-3, and J-13; (2) H-4, SD-12, and WT-2; or (3) SD-6 and H-5. Other combinations are also possible, and other wells could be expected to respond to long-term pumping tests. Because fractures and faults have preferred orientations, and can act as preferred flow pathways, quantitative studies require that more than one representative elementary volume of rock be sampled.

Based on the available potentiometric head data, flow from the proposed repository is likely to be in a southeasterly direction (i.e., along the natural hydraulic gradient) toward Fortymile Wash. This is the general direction of flow that was interpreted by panelists in a recent expert elicitation on the site's saturated zone (Geomatrix, 1998), and is also the flow pattern that is best supported by hydraulic head data. Southeasterly flow is the direction used in the NRC/CNWRA performance assessment model where saturated zone flow and transport are simulated in a series of stream tubes. Radionuclides reaching the saturated zone from the repository along this southeasterly flow path would migrate along fracture-dominated pathways in the tuff aquifers in the general direction of well J-12, and thence, travel southward in saturated alluvium toward the Amargosa Desert. The southeasterly flow path assumes that the fractured tuff aquifer is an equivalent porous medium at the site scale under isotropic conditions. Treatment of the aquifer as an equivalent medium at a large scale is supported by the pervasiveness in the tuffs of faults and fractures oriented in many directions and by results of long-term testing at the C-wells. The staff will continue our analysis of the previous and ongoing C-wells testing.

As noted above, groundwater flow in the tuff aquifer is dominated by structural features. This causes anisotropic conditions where structures may act as high- and/or low-permeability zones.

This is most evident at small spatial scales. At larger scales the hydrologic properties of interconnected fault and fracture networks are expected to dominate flow conditions. Because of uncertainties about large-scale anisotropy, current DOE simulations assume that ~10% of transport pathways never come into contact with saturated alluvium. Data from aquifer pumping tests in the C-well complex are now being analyzed to determine whether large-scale anisotropic effects are evident. There are presently no data concerning the isotropy of saturated alluvium.

The staff's current model is subject to revision as new site data are collected and analyzed. Due to sparse data in some areas and uncertainties in the interpretation, the staff continues to analyze whether there are other viable SZ conceptual flow models that can be supported by available data. For example, the staff is examining whether there is evidence of site-scale aquifer anisotropy that could shift SZ flow patterns significantly away from the direction of the observed southeasterly natural hydraulic gradient.

A promising new approach exists that may greatly improve the isotopic dating of groundwaters with the ^{14}C technique, leading to better estimates of average groundwater residence times. Residence time is related to average regional groundwater velocity. Thomas (1996) describes the separation of dissolved organic carbon from groundwater using reverse osmosis and ultrafiltration methods. The staff believes that this method should be applied to samples collected at YM to provide an independent estimate of the apparent groundwater velocities in the system and the average time of travel from principal recharge zones to YM. This technique, when applied to groundwater in the vicinity of Devils Hole, indicated that groundwater residence times in the carbonate aquifer feeding Devils Hole are about 2000-3000 years (Winograd, et al., 1997), significantly less than earlier estimates.

Information about flow conditions in the Paleozoic carbonate aquifer beneath YM is based on only one well, USW p#1. Heads in this well are about 22 m higher in the Paleozoic carbonate aquifer and lower volcanic confining units than in the Crater Flat tuffs (lower volcanic aquifer), indicating a strong upward gradient. Likewise, heads in the lower volcanic confining units in wells H-l and H-3 are also higher than in the Crater Flat Tuffs, providing evidence that significant upward hydraulic potentials probably exist over most of the site east of Solitario Canyon. This condition is favorable for waste isolation because an upward gradient, if maintained in the future, would protect the deep Paleozoic carbonate aquifers from contamination. DOE's cooperative drilling program with Nye County should provide timely additional data regarding the vertical gradients between the Paleozoic carbonate aquifers and overlying tuffs or alluvium. Large differences in groundwater chemistry (Oliver and Root, 1997) between the carbonate aquifer system and the Crater Flat tuffs suggest that upward fluxes are relatively small compared to those introduced by lateral flow within the tuffs.

Status and NRC Specified Path to Resolution: Open, pending review of DOE submittals (e.g., VA, data for alluvium and tuffs) and staff analysis of effects of large-scale anisotropy. The staff will determine what adjustments, if any, to general flow paths are warranted.

(3) Staff should determine whether DOE has provided a hydrologic assessment to describe likely causes of the "moderate hydraulic gradient" and the "large hydraulic gradient."

NRC Analysis: At or west of YM is a zone of relatively low permeability that tends to restrict flow from west to east. Based on current understanding, the SCF and associated splays are the most likely cause of the 45-m head change known as the "moderate hydraulic gradient." There is evidence that groundwater crosses the fault, but actual fluxes are not known. The tendency to restrict flow probably decreases toward the north as fault displacement decreases. The fault displacement reaches a minimum at a hinge point, about one km southwest of well G-2. When completed, well SD-6 located at the crest of YM should be used to conduct pumping tests beneath the western repository block near the Solitario Canyon fault, and to obtain estimates of transmissive properties beneath that part of YM. Hydraulic testing at SD-6 should provide new insights about the nature of the so-called "moderate hydraulic gradient."

Well WT-24 is currently being drilled to improve DOE's understanding of the so-called large-hydraulic gradient. The NRC believes that a sufficient understanding can be obtained through the drilling and testing of WT-24. Preliminary data show that a perched zone is present near the top of the Calico Hills in this well, and that the regional potentiometric surface is also more than 100 m higher than in wells immediately to the south.

Status and NRC Specified Path to Resolution: Open, pending submittal and staff review of DOE reports on the drilling and testing of wells WT-24 and SD-6. Preliminary water-level elevations have been reported (WT-24: 839.5 m; SD-6: 731.5) (personal communication, C. Glenn, NRC Onsite Representative). The data remain preliminary because the wells are still being constructed, and staff await formal reports from DOE on testing and data collection at these wells.

(4) Staff shall determine whether DOE has provided maps of approximate potentiometric contours for an area that, at a minimum, includes wells J-1 1 on the east, VH-1, VH-2, and the GEXA Well on the west, UE-29a #2 to the north, and domestic and irrigation wells south of Amargosa Valley (Lathrop Wells). Maps of regional and site-scale recharge and discharge should be provided, along with site-scale hydrostratigraphic cross sections constructed along the paths to the accessible environment, and flow-net analysis of the site-scale SZ.

NRC Analysis: TBD.

Status and NRC Specified Path to Resolution: Open, pending review of DOE's VA.

(5) Staff shall determine whether DOE has characterized key hydrologic parameters in the form of either probability distributions or deterministic bounding values. These parameters include transmissivity, hydraulic gradient, porosity (effective, matrix, and fracture), and effective aquifer thickness. DOE's parameters should be reasonably consistent with site data.

NRC Analysis: DOE is apparently using probability distributions to represent key hydrologic parameters in TSPA, an approach that is acceptable to the staff. Staff will review DOE submittals to determine whether the parameters used are reasonably consistent with site data.

Status and NRC Specified Path to Resolution: Open, pending review of DOE's VA.

(6) Staff shall determine whether DOE has used mathematical groundwater model(s) that incorporate site-specific climatic and subsurface information. Sufficient evidence is presented that the models were reasonably calibrated and that the physical system is reasonably represented. The fitted aquifer parameters should compare reasonably well with observed site data. Implicitly or explicitly simulated fracturing and faulting should be consistent with the data in the 3D geologic model. Abstractions should be based on initial and boundary conditions consistent with site-scale modeling (e.g., Czarnecki, et al., 1997) and the regional models of the Death Valley groundwater flow system (e.g., D'Agnese, et al., 1997a, b; U.S. Department of Energy, 1997). Abstractions of the groundwater models for use in PA simulations should use appropriate spatial- and temporal-averaging techniques.

NRC Analysis: TBD.

Status and NRC Specified Path to Resolution: Open, pending review of DOE's VA

(7) It will be acceptable for DOE to conservatively assume no wellbore dilution at a receptor location. If wellbore dilution is used, it should be demonstrated that reasonable assumptions have been made about well design, aquifer characteristics, plume geometry, withdrawal rates, and capture zone analysis for the receptor location.

NRC Analysis: Currently DOE is taking no explicit credit for wellbore dilution. This is acceptable to the staff but is inconsistent with a DOE-sponsored expert elicitation (Geomatrix, 1998), which concluded that significant dilution can be expected through well pumping. If DOE takes credit for wellbore dilution in future submittals, the staff will evaluate the information to determine if the acceptance criterion has been met.

Status: Resolved. The staff has no further questions at this time.

(8) It will be acceptable for DOE to conservatively assume no dilution due to dispersion, or no groundwater mixing below the repository footprint, and no mixing of the YM water with water from the north in Fortymile Wash. If intra-basin mixing of groundwater is used, it should be demonstrated that reasonable assumptions have been made about spatial and temporal variations of aquifer properties and groundwater volumetric fluxes. If dilution is simulated as dispersion in a numerical transport model, scale-dependent dispersivities, constrained by the analysis in Gelhar, et al. (1992), should be used.

NRC Analysis: The recent peer review of DOE's TSPA (DOE, 1998) commented that the saturated zone model used in the TSPA-VA is likely to result in a non-conservative estimate of dilution due to mixing along the flow path. The model assumes that radionuclides reaching the water table and transported in the groundwater would be subjected to widespread and uniform mixing in all of the stream tubes within the flow tube model. If only a small percentage of the waste packages fail, and if the failures are confined to a small area of the repository, which is probably one of the more likely scenarios, the radionuclides will more likely be confined to specific stream tubes and not uniformly mix or spread over all of the stream tubes in the flow tube model. Therefore, the presumed widespread and uniform mixing in the flow tube model is not conservative because it would result in more dilution due to mixing in the flow tube than the mixing that would take place.

For 20-km flowpaths, DOE appears to be using dilution factors that range from 1-100, with a median value of 12. These estimates, derived from the conclusions of three members of a five-member expert panel (Geomatrix, 1998), consider dispersion effects. The other two panel members did not estimate the dilution range. The estimates do not include the additional effects of dilution within wellbores or intrabasin mixing. The range and median appear to be conservative because they are reasonably low. The staff will assess DOE's treatment of dilution in the VA.

Status and NRC Specified Path to Resolution: Open, pending review of VA.

(9) Staff shall determine whether DOE has incorporated key conclusions regarding potential geothermal and seismic effects on the ambient SZ flow system (e.g., National Research Council, 1992; Craig, 1997; NWTRB, 1998).

NRC Analysis: TBD.

Status and NRC Specified Path to Resolution: Open, pending review of DOE's VA.

(10) It will be acceptable for DOE to use estimates and recommendations provided by expert elicitations (e.g., Geomatrix, 1998) as long as the expert elicitation is conducted and documented using the guidance in the Branch Technical Position on Expert Elicitation (NRC, 1996) or other acceptable approaches.

NRC Analysis: The expert elicitation on saturated zone flow and transport (i.e., Geomatrix, 1998) was conducted and documented in an acceptable way.

Status and NRC Specified Path to Resolution: Resolved. The staff has no further questions at this time.

(11) Staff shall determine whether the collection, documentation, and development of data, models, and computer codes have been performed under acceptable QA procedures. If not subject to an acceptable QA procedure, the data, models, and codes must have been appropriately qualified.

NRC Analysis: TBD.

Status and NRC specified path to resolution: TBD.

3.4.2 SC&A Evaluation of Whether DOE Can Meet NRC's Acceptance Criteria

The DOE presents its discussion of the saturated zone flow and potential dilution processes primarily in Sections 3.7, 4.1.12 and 5.7 of the TSPA-VA. The NRCs greatest concerns are related to a lack of data describing relevant groundwater flow processes. The NRC, however, apparently believes that currently planned activities (e.g., Nye County Well Program) will be sufficient to address most existing concerns. The only NRC recommendations that would be beyond the scope of DOE's current characterization plans is the use of the saturated zone testing strategy described in Reimus, et al. (1998). NRC also suggests, however, that new wells may not be needed. In any case, DOE should not have any major problems meeting NRC's Acceptance Criteria for the saturated zone if the practice of taking credit only for SZ dilution by a factor of 10 is preserved.

3.5 Matrix Diffusion in Saturated and Unsaturated Zones

Matrix diffusion is related to two of the key elements of the natural subsystems: (1) distribution of mass flux between fracture and matrix; and (2) retardation in water-production zones and alluvium. At YM, the process of matrix diffusion may impact repository performance because groundwater flow, away from the repository, occurs primarily in fractures that account for only a small fraction of total formation porosity. In such hydrologic systems, matrix diffusion can attenuate migration of radionuclides in two ways: (1) it can spread them physically from the flowing fractures into stagnant matrix pore water; and (2) rock matrix can provide a vast increase in mineral surface available for geochemical surface reactions (e.g., sorption) as compared to fracture surfaces alone. The extent to which matrix diffusion can affect repository performance is controlled by the rate of solute diffusion from fractures into rock matrix relative to the time scale for flow through the fracture system to the receptor point. When diffusion is very slow relative to the transport time, the impact is negligible in terms of solute arrival time, but there is a slight long-term attenuation of peak solute concentration. If diffusion is fast relative to transport time, the impact is a significant delay in solute arrival at the receptor point. At intermediate diffusion rates, the impact is a modest delay in initial solute arrival time with significant attenuation of solute concentration.

The Repository Safety Strategy (DOE 1998, p. 12) noted that concentrations of radionuclides in groundwater can be reduced by matrix diffusion and sorption. If matrix diffusion is limited, sorption can still occur on fracture walls, but the depletion effect will be much smaller.

3.5.1 NRC Acceptance Criteria and Resolution Status

In the NRC's Technical Review of a TSPA-LA, it will determine whether DOE has reasonably complied with the Acceptance Criteria listed below. The results of NRC's most recent compliance determinations are also presented.

(1) It will be acceptable for DOE to conservatively assume no credit for matrix diffusion in the UZ. If credit is taken, then matrix diffusion predictions are consistent with evidence for limited matrix diffusion in the UZ including: (i) geochemical data (e.g., Yang, et al., 1996b) that provide evidence of geochemical disequilibrium between matrix and fracture waters in the UZ at YM; and (ii) 36Cl evidence for rapid transport pathways to the repository horizon (e.g., Fabryka-Martin, et al., 1996b).

NRC Analysis: The UZ radionuclide transport sub-model that is currently used in the DOE TSPA model is described by Robinson, et al. (1997). From the model description, it is evident that effective diffusion coefficients are selected *a priori* and not correlated within the model to fracture or matrix saturation. Although it is possible to simply reduce the value of the selected diffusion coefficient to be consistent with reduced matrix and fracture saturation, no analysis is provided to show that selected diffusion coefficients are appropriate for the conditions modeled. Additionally, no analyses of the resultant geochemical differences between matrix and fracture water are provided. Thus it is not possible at this time to assess whether the DOE method of abstracting matrix diffusion into UZ radionuclide transport is suitable for predicting repository performance.

Available information for YM indicates that the fracture-matrix interface area is limited to the wetted surface area within fractures. Similarly, effective diffusion coefficients in the UZ are saturation-dependent and should be proportional to the effective saturated cross-sectional area through which solutes can diffuse. Furthermore, TSPA model predictions should be consistent with UZ geochemical data (e.g., Yang, et al., 1996), which suggest that waters within rock matrix at YM have different geochemical signatures than fracture waters; predictions should also be consistent with 36Cl evidence (e.g., Fabryka- Martin, et al., 1993) for rapid transport pathways to the repository horizon.

DOE should clearly document the technical basis for assumptions used to estimate the transfer term for fracture-matrix exchange in the dual permeability model (DKM) for UZ transport. The staff has concerns that the residence time transfer function (RTTF) for the dual continuum model is overestimated, because assuming an immobile reservoir neglects the transfer function accounting for particles moving from the matrix to the fracture.

Status and NRC Specified Path to Resolution: Open, pending review of DOE's VA.

(2) It is acceptable for DOE to conservatively assume that no matrix diffusion will occur in the SZ (i.e., that all solutes will remain in fractures) during transport through saturated fractured rock aquifers. DOE's inclusion of matrix diffusion in SZ transport models for YM should be reasonably supported by both field and laboratory observations. Acceptable field and lab observations include tracer tests that are conducted over different distance scales and flow rates with multiple tracers of different diffusive properties. Transport models should reasonably match the results of the field tracer tests. Rock matrix and solute properties used to justify the inclusion of matrix diffusion in TSPA models fall within a range that can be supported by laboratory data.

NRC Analysis: The staff believes there is much greater potential for radionuclide retardation in saturated alluvial deposits than in fractured tuffs. From the proposed repository to potential receptors at a distance of 20 km, flowpaths will probably include significant amounts of saturated alluvium. Matrix diffusion in the Tertiary tuffs would then be of minor significance.

DOE's current assumptions about matrix diffusion are supported to some extent by field and laboratory results to date. However, the amount of matrix diffusion claimed by DOE from these results has been disputed by the staff and others. A clearer demonstration of the matrix diffusion phenomenon can be made by (1) using tracers with more variation in physical properties and by testing over different length scales and flow rates, and (2) by demonstrating the degree to which matrix diffusion can actually occur within fractured welded and moderately welded tuffs that are known to act as significant flow zones at YM. Zones that contribute to flow in wells have been identified through borehole logging and hydrologic testing. Samples from those zones should be subjected to visual testing techniques of the type described by researchers like Tidwell, et al. (1997).

DOE is assuming that matrix diffusion in the SZ occurs over a range of porosity described by a log-triangular distribution that ranges from 0.0001 to 0.2, with a mean of 0.02 (2%). DOE is simplifying the treatment of matrix diffusion by assuming that the range and mean are equivalent to that assumed for effective (advective) porosity and appear to be reasonably conservative with respect to field and lab tests of matrix diffusion and porosity. However, DOE's basis for selecting a log-triangular distribution needs to be clarified and will be examined in the staff's review of the VA.

In DOE's evaluation of C-wells tracer tests, the staff is concerned that use of the 50% relative solute concentration arrival times to derive the range of effective porosities has inherent non-conservatism that could be avoided by basing the effective porosity approach on relatively early solute arrival times (e.g., about 10% relative solute concentration). Finally, it appears that, although the matrix diffusion behavior is different for each solute, DOE is using the same effective porosity for all solutes. If DOE intends to neglect this variation in solute behavior, the staff recommends using the effective porosity derived from the least diffusive solute likely to influence performance.

Status and NRC Specified Path to Resolution: Open, pending review of DOE's VA.

(3) If used, DOE's expert elicitations should be conducted and documented using the guidance in the Branch Technical Position on Expert Elicitation (NRC, 1996), or other acceptable approaches.

NRC Analysis: TBD.

Status and NRC specified path to resolution: TBD.

(4) Staff shall determine whether the collection, documentation, and development of data, models, and computer codes have been performed under acceptable QA procedures. If they were not subject to an acceptable QA procedure, the data, models, and codes must have been appropriately qualified.

NRC Analysis: TBD.

Status and NRC specified path to resolution: TBD.

3.5.2 SC&A Evaluation of Whether DOE Can Meet NRC's Acceptance Criteria

The sections in the TSPA-VA that pertain to matrix diffusion processes include 2.2.5, 3.6.1.2, 3.7.1.1, and 5.6.1. The NRC indicates that DOE could conservatively assume no credit for matrix diffusion in the unsaturated zone. Although DOE has assumed that matrix diffusion occurs in the unsaturated zone for the TSPA-VA, DOE has also shown *via* sensitivity studies that the influence of matrix diffusion on overall system performance is small (Section 5.6). Therefore, rather than trying to defend transfer values as the NRC's Acceptance Criteria require, DOE may simply ignore or assign low values to matrix diffusion processes for a license application. In any event, DOE should be able to satisfy NRC's Acceptance Criteria for diffusion in the unsaturated zone.

With respect to matrix diffusion in the saturated zone, the DOE conservatively assumed in the TSPA-VA that it did not occur. This assumption is fully consistent with the NRC Acceptance Criteria. Furthermore, although DOE did not explicitly perform sensitivity analyses on matrix diffusion in the saturated zone it is likely that matrix diffusion would have little impact on the overall performance.

3.6 Radionuclide Transport Through Porous Rock

When radionuclides pass through porous rock, the interactions between the dissolved radionuclides and the rock surfaces (e.g., sorption) result in retardation of the velocity of the radionuclides relative to the velocity of groundwater. The large surface areas of the porous medium tend to enhance sorption and consequently retardation. Furthermore, for those radionuclides whose sorption reactions may be kinetically inhibited, the slower average linear velocities of groundwater flow in porous media promote the solid-liquid interaction. If the radionuclides exist instead as particulates or as colloids, they may be filtered out as groundwater flows through the constricted pores of the matrix. Sorption of radionuclides on solids and filtration of radiocolloids and particulates in the matrix reduces the radionuclide concentration in the liquid. However, the low permeabilities of the matrix of some hydrostratigraphic units at Yucca Mountain may make some rock inaccessible to radionuclide-contaminated water during the timeframe of repository performance.

3.6.1 NRC Acceptance Criteria

The approach that recent performance assessment efforts have used to simulate radionuclide transport in porous rock involves first establishing a groundwater flow field. This flow field is generated as a result of hydrologic modeling of the Yucca Mountain system using site-specific parameters, and may have one, two, or three dimensions, depending on the purpose of the modeling effort and the available data. The flow field representing the spatial distribution of groundwater velocities is then adjusted by dividing the velocity vectors by the retardation factor, R_f, for each radionuclide, to yield the radionuclide velocity fields. Current approaches model the groundwater flow field as a dual continuum representing both fracture and matrix flow at every point in the system.

The following Acceptance Criteria apply to evaluating the DOE estimates and consideration of radionuclide transport through porous rock:

(1) For the estimation of radionuclide transport through porous rock, DOE has:

a. Determined, through performance assessment calculations, whether radionuclide attenuation processes such as sorption, precipitation, radioactive decay, and colloidal filtration are important to performance

b. (i) Assumed K_d is zero and radionuclides travel at the rate of groundwater flow, if it has been found that radionuclide attenuation is unimportant to performance (in which case, Acceptance Criteria 2 and 3 do not have to be met) or,
(ii) demonstrated that Criterion 2 or 3 has been met, if radionuclide attenuation in porous rock is important to performance.

(2) For the valid application of the K_d approach, using the equation $R_f = 1 + \rho K_d/n$, DOE has:

a. Demonstrated that the flow path acts as an isotropic homogeneous porous medium.

b. Demonstrated that appropriate values for the parameters, K_d, n or θ, and ρ have been adequately considered (e.g., experimentally determined or measured).

c. Demonstrated that the following assumptions (i.e., linear isotherm, fast reversible sorption reaction, and constant bulk chemistry) are valid.

(3) For the valid application of process models such as surface complexation, ion exchange, precipitation/dissolution, and processes involving colloidal material, DOE has:

a. Demonstrated that the flow path acts as an isotropic homogeneous porous medium.

b. Demonstrated that appropriate values are used for the parameters in process models.

c. (i) Demonstrated that the three implicit assumptions (see 2.c.) are valid, if process models are intended to yield a constant K_d for use in the retardation equation; or (ii) determined transport in a fully coupled dynamic system (e.g., PHREEQC, MULTIFLO, HYDROGEOCHEM, etc.).

(4) Where data can not be reasonably or practicably obtained, expert judgment has been used, and expert elicitation procedures have been adequately documented. If used, expert elicitations were conducted and documented in accordance with the guidance in NUREG-1563 (U.S. NRC, 1996b) or other acceptable approaches.

(5) Data and models have been collected, developed, and documented under acceptable Quality Assurance (QA) procedures (e.g., Altman, et al., 1988), or if data were not collected under an established QA program, they have been qualified under appropriate QA procedures.

3.6.2 Status of Issue Resolution at the NRC Staff Level

Most of the Yucca Mountain geochemical work in the past twenty years has been directed toward determining the retardation of radionuclides in porous rock. Significant progress has been made in addressing this issue, which is important to waste isolation and repository performance. However, there have been major changes in the conceptualization of the geologic setting of the repository that impact the relative importance of this issue, including consideration of the point of compliance up to 20 kilometers away from the repository. The greater average infiltration results in a greater proportion of the flux bypassing the sorptive porous rock by flow in fractures. A 20 km point of compliance would result in the need to consider the alluvium along with porous and fractured rock. These major changes reduce the relative importance of radionuclide transport in porous rock on performance assessment.

The NRC considers that the subissue has been resolved for certain radionuclides but not for others. Some of the radionuclides for which the issue has not been resolved on the staff level may be important to performance.

The NRC finds that the approach adopted by LANL to determine minimum K_d values is logical and defensible. By performing batch sorption tests using site-specific materials, followed by confirmatory tests to establish the validity of the assumptions needed for the constant K_d approach, and then selecting the minimum K_d from all the tests, an acceptable value can be obtained.

In summary, NRC chose three radionuclides as examples to highlight successes and areas needing further work. They are neptunium, plutonium, and uranium. The minimum K_d approach has worked well for neptunium. The staff recognizes that multiple tests have been performed to establish reasonable K_d values for this radionuclide. Consequently, this issue is resolved for neptunium. On the other hand, although both batch sorption tests and flow-through column tests have been performed to determine a minimum K_d for plutonium, significant inconsistencies have occurred. The NRC staff recognizes plutonium as problematic and encourages further work to establish defensible K_d values. For uranium, geochemical modeling suggests that a uranyl silicate phase, soddyite, could precipitate from solution, given the initial groundwater composition. Eliminating the possibility that processes other than sorption (e.g., precipitation) may be contributing to the removal of a radionuclide from solution is necessary for establishing a valid K_d. On the other hand, the thermodynamic modeling could be in error based on parameter uncertainties. To date, it does not appear that flow-through column tests were performed with uranium. Consequently, the NRC does not believe that this issue has been resolved.

3.6.3 SC&A Evaluation of Whether DOE Can Meet NRC's Acceptance Criteria

Radionuclide transport and sorption through porous rock are discussed primarily in sections 3.6.2.3 and 3.7.2.2 of DOE's 1998 TSPA-VA. Essentially, DOE applies a probabilistic type approach where the statistical distributions for the radionuclides range from no retardation to some upper bound of retardation. It would appear that, at least conceptually, the NRC would not have a problem with this approach, provided that the mean, distribution, and upper bound are adequately supported by actual data. The TSPA-VA indicates that the only additional sorption work planned pertains to measuring sorption properties in the alluvium. This activity would not address NRC's concerns about uranium and plutonium. The TSPA-VA indicates, however, that the DOE had not received NRC's Issue Resolution Status Report - Key Technical Issue for Radionuclide Transport at the time DOE was planning future investigations. Therefore, DOE should be able to accommodate NRC's concerns by the time of a license application submittal.

3.7 Radionuclide Transport Through Alluvium

Current conceptual models of the alluvium incorporated in performance assessments reflect limited information concerning the physical and chemical conditions of alluvium. For example, in the NRC's TPA 3.1 (NRC, 1998), the alluvium is assumed to be crushed tuff similar to the material used in batch sorption experiments. The DOE model abstraction assumes flow as in a sand column driven by the hydraulic gradient. Furthermore, in the TSPA-VA, DOE assumes there are no preferential pathways in the alluvium. This assumption has not yet been tested. However, the occurrence of cut and fill structures formed in the alluvium by braided streams as evident in the walls of Forty Mile Canyon may suggest that preferred pathways exist in the alluvium with the potential to reduce mixing and dilution.

3.7.1 NRC Acceptance Criteria

The DOE considers radionuclide transport a key performance attribute of the natural barrier system in the proposed repository. Retardation of radionuclides through alluvium constitutes a key element of the DOE performance assessment. The NRC indicates that DOE must adequately estimate the transport characteristics of the Yucca Mountain site and appropriately consider radionuclide transport in its assessments of repository performance. NRC's review process is designed to determine which transport processes have been addressed or assumed by DOE. The review will first identify, whether or not the selected retardation processes are appropriate to the Yucca Mountain system, and second, whether the processes are addressed adequately for radionuclides of concern.

The following Acceptance Criteria, which are the same as those for radionuclide transport through porous rock, apply to evaluating the DOE estimates and consideration of radionuclide transport through the alluvium:

For the estimation of radionuclide transport through alluvium, DOE has:

a. Determined, through performance assessment calculations, whether radionuclide attenuation processes such as sorption, precipitation, radioactive decay, and colloidal filtration are important to performance.

b. (I) Assumed Kd is zero and radionuclides travel at the rate of groundwater flow, if it has been found that radionuclide attenuation is unimportant to performance in which case, Acceptance Criteria 2 and 3 do not have to be met, or (ii) demonstrated that Criterion 2 or 3 has been met, if radionuclide attenuation in alluvium is important to performance.

For the valid application of the K_d approach, using the equation $R_f = 1 + \rho K_d/n$, DOE has:

a Demonstrated that the flow path acts as an isotropic homogeneous porous medium (see USFIC IRSR, deep percolation on the issue of describing methods of estimating matrix properties as parameters).

b. Demonstrated that appropriate values for the parameters, K_d, n or θ, and ρ have been adequately considered (e.g., experimentally determined or measured).

c. Demonstrated that the three implicit assumptions (i.e., linear isotherm, fast reversible sorption reaction, and constant bulk chemistry) are valid.

For the valid application of process models such as surface complexation, ion exchange, precipitation/dissolution, and processes involving colloidal material, DOE has:

a. Demonstrated that the flow path acts as an isotropic homogeneous porous medium (see USFIC IRSR, deep percolation on the issue of describing methods of estimating matrix properties as parameters).

b. Demonstrated that appropriate values are used in process models.

c. Demonstrated that the three implicit assumptions (as in 2.c.) are valid, if process models are intended to yield a constant K_d for use in the retardation equation; otherwise, determined transport in a fully coupled dynamic system (e.g., PHREEQC, MULTIFLO, HYDROGEOCHEM, etc.).

Where data can not be reasonably or practicably obtained, expert judgment has been used, and expert elicitation procedures have been adequately documented. If used, expert elicitations were conducted and documented in accordance with the guidance in NUREG-1563 (U.S. NRC, 1996b) or other acceptable approaches.

Data and models have been collected, developed, and documented under acceptable QA procedures (e.g., Altman, et al., 1988), or if data were not collected under an established QA program, they have been qualified under appropriate QA procedures.

3.7.2 <u>Status of Issue Resolution at the NRC Staff Level</u>

The status of this issue is tied closely to that of the previous issue. However, additional uncertainty results from very limited information collected to date on the mineralogy, groundwater, chemistry, and physical flow systems of the alluvium. Past efforts have focused on characterizing the geologic media within 5 kilometers of the repository because of the provisions of the then-applicable 40 CFR Part 191. With the increase in the length of the flowpath to the biosphere to 20 kilometers, now seen as consistent with draft 10 CFR Part 63, a substantial section of relatively uncharacterized geologic media has been added to the system.

Although, like DOE, the NRC has assumed in earlier modeling that the alluvium acts as a homogeneous porous medium, the NRC also recognizes that little or no information is available to support that assumption. Furthermore, the NRC believes that treating the alluvium as a homogeneous porous medium may be nonconservative.

The NRC expects that the series of boreholes to be drilled by Nye County in the alluvium will provide significant information about its geologic and hydrologic characteristics. The mineralogy will likely reflect that used in batch sorption experiments for determining sorption coefficients for radionuclides in tuff. If that is so, the NRC believes that the laboratory work needed to address the previous issue (i.e., retardation in porous rock) will also address the retardation issues in the alluvium.

The NRC notes that the DOE will need to defend its conceptualization of the alluvium. If the alluvium is a composite of cut and fill structures resulting from the accretion of braided streams, preferred pathways limiting water-rock interaction may result. If, on the other hand, the alluvium is homogeneous, the application of experimentally determined K_ds to calculate retardation factors would be appropriate. The NRC indicates that resolution of this issue will await the geologic and hydrologic information to be collected.

3.7.3 SC&A Evaluation of Whether DOE Can Meet NRC's Acceptance Criteria

Radionuclide transport and sorption through the alluvium are discussed primarily in sections 3.6.2.3 and 3.7.2.2 of the TSPA-VA. Essentially, DOE applies a probabilistic type approach where the statistical distributions for the radionuclides range from no retardation to some upper bound of retardation. As discussed under the issue Transport through Porous Media, it would appear that, at least conceptually, the NRC would not have a problem with this approach, provided that the mean, distribution and upper bound are adequately supported by actual data. The TSPA-VA indicates that sorption work on the alluvium is currently planned. NRC also expects the well drilling program in Nye County to shed light on the general properties of the alluvium. If this program fails to provide sufficient understanding of the potential dilution in the alluvium, based on other similar situations, it would appear that the DOE could satisfy NRC Acceptance Criteria by not taking as much credit for dilution in the saturated zone. Section 5.7.1 of the TSPA-VA, however, indicates that dilution in the saturated zone is one of the most sensitive parameters and DOE would consequently like to take as much credit as possible.

3.8 Radionuclide Transport Through Fractured Rock

Recent site characterization activities involving the radioisotopes ^{36}Cl and ^{3}H provide evidence suggesting fast pathways of groundwater flow through the unsaturated zone (Fabryka-Martin, et al., 1996). These fast pathways are proposed to occur as a result of flow down faults and fractures. Also, responses from adjacent wells in large-scale hydrologic pump tests (C-Wells) suggest preferential pathways may exist in the saturated zone at Yucca Mountain (Geldon, et al., 1997). If preferential pathways exist from the repository to the critical group, performance may be adversely affected, because portions of the geologic barrier would be bypassed.

In predicting flow and transport through the unsaturated zone, the TSPA-VA takes no credit for retardation of radionuclides in fractures. The rationale for assigning no retardation in the fractures is based on the hypothesis that there is limited capacity for sorption along fractures, and average linear velocities in fractured rock are high, limiting time for interaction between the dissolved radionuclides and the sorbing minerals lining the fracture walls. However, the presence of specific fracture-lining minerals may provide significant opportunity for sorption of specific radionuclides. For example, the manganese oxyhydroxides may strongly sorb plutonium, uranium, and americium; calcite may strongly sorb or coprecipitate neptunium (Triay, et al., 1996).

Since the TSPA-VA does not explicitly incorporate fractures in predicting flow and transport through the saturated zone, the potential sorption effects of the fractures and matrix are, in essence, lumped into a single value. The DOE addresses the associated uncertainty by assigning a range, mean, and distribution to the sorption values (i.e., K_d's) for each of the hydrologic units.

3.8.1 NRC Acceptance Criteria

DOE considers radionuclide transport a key performance attribute of the natural barrier system in the proposed repository. Retardation of radionuclides in fractures in the unsaturated zone and in the saturated zone constitutes a key NRC consideration in evaluating DOE's performance assessment. NRC notes that DOE must adequately estimate the transport characteristics of the Yucca Mountain site and appropriately consider radionuclide transport in its assessments of repository performance. NRC's review process is designed to determine which transport processes have been addressed or assumed by DOE. The NRC will first identify whether the selected retardation processes are appropriate to the Yucca Mountain system, and second, whether the processes are addressed adequately for those radionuclides of concern.

NRC indicates that Acceptance Criteria for evaluating the DOE estimates and consideration of radionuclide transport through fractured rock will be developed in FY99.

3.8.2 Status of Issue Resolution at the NRC Staff Level

NRC has yet to develop the acceptance criteria for this issue, although it expects that to develop them in FY99. DOE has performed some experiments using fractured rock. Whereas the retardation factor in fractures is assumed to be 1 (i.e., no sorption) in performance assessments because of the uncertainty with regard to radionuclide transport in fractured rock, preliminary experiments suggest that some retardation occurs. For example, neptunium experiments have been performed and show reduced recovery and a delay in the breakthrough relative to tritium and technetium.

3.8.3 SC&A Evaluation of Whether DOE Can Meet NRC's Acceptance Criteria

Although NRC has not developed the Acceptance Criteria for transport through fractured rock, it is unlikely that DOE will have trouble meeting the criteria for several reasons, including:

(1) DOE is unlikely to assume sorption on fracture surfaces, particularly since it would be very difficult to establish actual values and because not that much would be gained in terms of performance since the fracture surface areas are so small, relative to the matrix.

(2) The uncertainty associated with statistical distributions of the sorption processes (i.e., K_d's) in the matrix would capture the potential effects of sorption on the fractures.

4.0 SUMMARY AND CONCLUSIONS

As part of NRC's regulatory oversight process, it has developed a number of Acceptance Criteria for issues considered key to DOE's performance assessment activities. SC&A reviewed the TSPA-VA, the NRC's criteria, and the current acceptance status to evaluate DOE's ability to produce results that will be defensible under regulatory reviews. Based on SC&A's review, no areas are apparent in which DOE will have difficulty in meeting NRC's acceptance criteria for groundwater flow and radionuclide transport in the unsaturated and saturated zones. However, additional data will be needed to confirm DOE's models and parameter values.

A principal reason that DOE can expect to meet the NRC acceptance criteria for ground water flow and radionuclide transport during the 10,000-year period is that the criteria are worded to allow, if not in fact to encourage, conservative assumptions that take little or no credit for contributions to repository performance, and DOE has, at least in the TSPA-VA, adopted this stance. The criteria require adequate characterization of the "input factors," which are climate conditions, infiltration rate, and the deep percolation rate. They require highly reliable characterization of the "output factors," i.e., those which could contribute to repository performance, including:

- Slow flow in the UZ
- Holdup in the UZ
- Matrix diffusion in the UZ, SZ, and tuff
- Dilution, dispersion, and mixing under the repository footprint and along the stream tubes
- Retardation in porous rock and alluvium
- Dilution in the well used by the dose receptor

In the TSPA-VA, DOE took credit only for dilution during transit of the stream tubes by a factor of 10 for the base case. This strategy eases the burden of demonstrating compliance with the acceptance criteria for flow and radionuclide transport in the hydrologic regime, but it puts the burden of overall system performance heavily on the Engineered Barrier System. Since the TSPA-VA also took no credit for features of the EBS that could contribute to performance but have associated uncertainty, such as restricted seepage into packages and in-package dilution, the burden of repository performance in the TSPA-VA analysis was mainly on the waste package and the spent fuel cladding. Revision of the database and its contribution to values of parameters used in TSPA models will require additional site characterization data.

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APPENDIX B

MODELING OF WASTE PACKAGE DEGRADATION IN THE TSPA-VA

MODELING OF WASTE PACKAGE DEGRADATION IN THE TSPA-VA

1.0 SUMMARY

The Waste Package Degradation section of the Viability Assessment of a Repository at Yucca Mountain, together with supporting documents, is reviewed here for the purpose of determining the adequacy of the DOE methodology for arriving at a waste package (WP) design that will be defensible in the regulatory environment. This review reveals inadequacies in the TSPA-VA calculations of the corrosion performance of the CAM outer barrier and the CRM inner barrier of the base case waste package (WP) design. The effects of free-falling drip velocity, salt deposits, and corrosion product spalling are not taken into account for the CAM performance, and treatment of the CRM inner barrier corrosion does not adequately account for the likely establishment of an aggressive environment in the crevice formed at the CRM surface under dripping conditions. Recalculation of the base case WP design performance using conservative assumptions for dripping conditions resulted in times to first breach of the WP of 2814 - 2975 years, as compared to the overly optimistic TSPA-VA range of 2700 - one million years. The DOE "defense in depth" strategy of employing two barrier materials subject to different degradation mechanisms to offset uncertainties appears to be faulty if one of the materials (i.e., carbon steel) offers little protection.

Although the DOE TSPA-VA base case design appears to provide inadequate performance, several alternate designs discussed in the TSPA-VA have the potential to produce results that will be defensible under the regulatory reviews, even when very conservative, upper-bounding corrosion rates are applied. Nearly an order of magnitude improvement in performance life (to over 22,000 years) can be obtained by shifting the CRM (Alloy 22) barrier from inside the CAM (carbon steel) barrier to the outside of the WP. The reason for this is the excellent corrosion resistance of Alloy 22 when it is corroded by a general corrosion mechanism as opposed to much higher (25X) rates when it corrodes by oxidizing, crevice corrosion conditions under the carbon steel CAM. The other, more expensive alternate designs are calculated to provide over 42,000 years of resistance to penetration. Also, it is believed that installation of an Alloy 22 drip shield would contribute an additional 20,000 years of resistance to WP penetration if this were needed. In contrast, the use of a backfill does not appear to improve WP performance significantly.

DOE recognizes that large uncertainties remain in the area of WP degradation, which the NRC considers to be the most important issue in the total system performance of the repository. The extensive DOE test program currently underway should strongly contribute to resolving many of the remaining uncertainties associated with the repository performance of barrier materials.

The TSPA-VA goal to produce a transparent document has not been achieved because it is not readily apparent to the reader how most of the final results and conclusions were reached. Implementation of the mathematical models into the computer codes is, in general, very fuzzy and not explained. The implication is that the reader should simply accept the results of the computer calculations. DOE needs to make a greater effort in this area.

2.0 INTRODUCTION

The NRC views the waste package (WP) design element that provides radionuclide containment as the most important issue in the total system performance of the repository (IRSP98, p.9). Corrosion is anticipated to be the primary cause for degradation of the WP engineered barrier under normal conditions (i.e., excluding disruptive seismicity, faulting or volcanism (IRSP98, p.19). Long-term laboratory corrosion test data and field performance experience for the candidate WP materials are limited; hence the models for WP performance have large uncertainties (WPDMA, p. 5-5). To address this problem, DOE employed a panel of recognized engineers and scientists to assist in the development of the degradation models (WPDEEe). However, the experts were not able to dispel many uncertainties; examples of this are (1) because of the limited data available for the corrosion resistant inner barrier, the experts assigned a large range of uncertainty to the general and localized corrosion rates for this material (WPDEEe, p. 4-6) and (2) the experts were not able to establish the inner barrier surface crevice solution chemistry for the degradation model (WPDMA, p.5-28).

This review focuses on the uncertainties in the corrosion data used as input to the DOE waste package degradation model and on any uncertainties introduced by the models themselves. The two DOE texts that are of primary concern in this review are:

- Section 3.4, Waste Package Degradation, TSPA-VA, Vol.3, December, 1998 (TSPA98)
- Chapter 5, Waste Package Degradation Modeling and Abstraction, TSPA-VA Analyses Technical Basis Document, November 13, 1998 (WPDMA)

A third document was consulted because of the importance of its input to the Viability Assessment:

- Waste Package Degradation Expert Elicitation Project (WPDEE), Rev.1, June 1998 (WPDEEe)

The stochastic waste package degradation model incorporates the following individual models (WPDMA, p.5-132):

- Humid -air general corrosion model for the CAM outer barrier
- Humid -air "roughness" factor (or localization factor) model for the outer barrier
- Aqueous general corrosion model for the outer barrier
- Aqueous roughness factor for the outer barrier
- Aqueous pitting corrosion model for the outer barrier when contacted with an alkaline solution (pH 10 or higher)
- General corrosion model for the CRM inner barrier without drips
- General corrosion model for the CRM in the presence of drips
- Localized corrosion (pitting and crevice corrosion) model for the CRM inner barrier

Each of these models will be discussed below in terms of uncertainties associated with the data and the models employed. But before undertaking this discussion, it may be well to review the sequence of events envisioned for the performance of the TSPA-VA waste package design, which consists of an outer barrier of corrosion allowance material (CAM), i.e., 10 cm thick carbon steel, and an inner barrier of corrosion resistant material (CRM), i.e., 2 cm thick Alloy 22. Following emplacement in the repository, waste packages will be exposed, according to the current base case scenario, to a period of dry oxidation followed by a period of humid air corrosion, which, in turn, will be followed by a period of aqueous corrosion.

Many uncertainties are associated with the environmental conditions to which waste packages will be exposed throughout these various periods, and the analysis presented below necessarily involves a number of assumptions. The bases for many of these assumptions have been presented in the WPDEE workshops (WPDEEa), which appear to reflect the most recent thinking within the DOE program. Two key relationships, the drift temperature/time profile and the relative humidity/time profile, were presented as reference conditions by D. Stahl at the second WPDEE workshop (WPDEEb). The conditions cited by Stahl were for the upper drift wall, which are assumed here to be similar to those at the waste package surface. WPDMA, Figures 5-57 and 5-58, present a newer, broader range of curves for conditions at the WP surface, but these encompass Stahl's reference conditions, which will be used to define the scenario corrosion periods in this discussion.

Due to heating of the repository, the relative humidity (RH) is expected to drop quickly to very low levels upon closure of the repository, and not return to levels where humid air corrosion can occur, i.e., at 70% RH (WPDMA, p.5.30), until after 550 years have passed. Metal losses on the carbon steel outer surface due to dry oxidation during this initial 550-year period are either unknown or expected to be very low according to the WPDEE experts, but actual oxidation rates were not specified (WPDEEe). Two of the five experts involved did express a concern about the possibility of spalling, which would enhance oxidation rates, but they offered no quantitative assessments. The tentative conclusion adopted in this review is that dry oxidation losses will be negligible, which agrees with the approach of the VA analysis.

3.0 DISCUSSION OF THE CORROSION MODELS

3.1 Humid Air General Corrosion Model for the CAM Outer Barrier

The value of 70% RH selected in the TSPA-VA for initiation of humid air corrosion appears to be somewhat high based on estimates proposed by the elicitation experts (WPDEEe, Fig. 3-2), and therefore, it may not be sufficiently conservative. However, the VA states that future TSPA analyses may incorporate the effects of more corrosive environments, such as salt precipitation in moisture refluxing conditions (WPDMA, p. 5-31). The use of Equation 5.8 (WPDMA, pp. 5-34 and 5-104) to model humid air corrosion is accepted here as reasonable.

In this review, the corrosion performance of the waste package for each of the various corrosion models is calculated in a simplified way, and the final, summed results are compared with those obtained by the much more elaborate VA methodology. (The computer codes employed by DOE will not be examined in this review because the reviewer is not qualified to do so, and because the codes do not appear to be easily accessible.) First, considering only RH effects, the duration available for humid air corrosion is from 550 years to 2000 years, at which point the RH rises to 90% and the onset of aqueous corrosion begins (WPDMA, Figs. 5-50 and 5-51). However, because the temperature levels remain above the boiling point during this period, no humid air corrosion should occur (TSPA98, p. 3-85).

3.2 Humid Air Roughness Factor for the CAM Outer Barrier

The VA base case analysis is modeled with a roughness factor of 1.50 and a standard deviation of 0.25 based on the WPDEE recommendations. This value is considered reasonable, although it will not be used in this review because, as noted above, humid air corrosion is not expected to occur.

3.3 Aqueous General Corrosion Model for the CAM Outer Barrier

The temperature threshold for aqueous corrosion initiation of the CAM is given in the VA as a cumulative distribution function (CDF) varying from 95 to 150 degrees C (WPDMA, Fig. 5-47). This distribution is believed to be possible, although the uncertainties associated with it are considerable. However, for the purpose of this review's simplified corrosion calculations, the value of 100 degrees C will be used below.

Equation 5-13 (WPDMA, pp. 5-40 and 5-104) is the model for the base case aqueous corrosion calculations . The constants in this equation were determined by fitting selected aqueous general corrosion data. Unfortunately, the temperature dependence of corrosion was based on short-term corrosion data for mild steel in distilled water, which is much less hostile than natural lake and river waters representative of the ambient temperature data employed. The VA claims the temperature dependence was "scaled" to be consistent with the natural water's performance, but no description of how this was done was provided (WPDMA, p. 5-39). This omission does not inspire confidence in the model.

All of the WPDEE experts agreed that drips will be very important to the corrosion processes and rates of corrosion. This review will be concerned only with the case of dripping onto the waste packages. The spatial distribution, frequency, persistence, and composition of the dripping water are all important (and still uncertain) aspects of the drip scenario. Drips falling on the WP surface when that surface is still relatively hot will evaporate and leave behind hydrated salt deposits, including chlorides, which could conceivably reach saturated chemistries and cause accelerated corrosion. However, effects of salts and chlorides are not included in the models. The TSPA-VA admits that this is a nonconservative approach to the modeling and states that additional data and analysis could help reduce uncertainties (WPDMA, p. 5-137; TSPA98, pp.3-85, 3-86). Another problem with the model is that it does not consider the effects of drip velocity. The calculated free-fall velocity of drips from the drift ceiling is predicted to increase the corrosion rate by a factor of seven times based on use of a published curve on the effect of solution velocity (CCC63). Finally, the possibility (or even probability) of spalling of the CAM corrosion products would lead to accelerated corrosion of the CAM. D. Shoesmith, one of the WPDEE experts, stated that persistent drips and the removal of corrosion products can cause CAM corrosion rates that are 10 times those of aqueous corrosion (WPDEEe, p. 3-9). This is another factor that is not considered in the TSPA VA model.

Examples of field corrosion of steel tanks and pipe have been cited that indicate penetration failure times for 10 cm thick carbon steel ranging between 13 and 5714 years for various aqueous environments (WPDEEa, N. Sridhar presentation). However, a corrosion rate for carbon steel of 533 μm/year, as given by the TSPA-VA model maximum (WPDMA, Fig. 5-19), will be assumed here for calculating the CAM degradation. Although this rate is based on relatively short-term tests, it is believed that the above-cited tendency of carbon steel corrosion products to spall off the steel surface justifies a conservative linear extrapolation of this rate to longer times. The result is that the 10 cm thick carbon steel CAM will corrode away in 188 years, i.e., 2188 years after emplacement. Furthermore, as noted above, if drips begin to fall on the waste package with the onset of high humidity levels at the 2000 year point, the free-falling drip velocity will increase the corrosion rate by a factor of seven in which case CAM penetration will occur after only 27 years, i.e., 2027 years after emplacement. In contrast, the TSPA-VA starting point for CAM breaching is 980 years, with all CAM barriers failing by 7000 years (WPDMA, p. 5-105)

3.4 Aqueous Roughness Factor Model for the Outer Barrier

The TSPA-VA value for the roughness factor is 1.5 with a standard deviation of 0.25 (WPDMA, Table 5-10). This value appears to be a little low in view of the difference of opinion of the WPDEE experts (WPDMA, p. 5-39 discussion and Fig. 5-14), but it is not unreasonable. However, for purposes of the corrosion penetration calculations, a value of 1.0 is assumed here.

3.5 Aqueous Pitting Corrosion Model for the Outer Barrier for pH = or > 10

While the concrete liner is intact, the pH of water passing through it could be increased to above 10, but J. Payer has made the argument that the concrete buffering capacity will be quite limited and will be quickly used up, and the WPDEE experts generally agreed with this conclusion (WPDEEb). Moreover, A. Van Luik (a DOE representative) has commented that cracks will be built into the concrete, and thus plenty of water will be able to enter the repository (NFPEB98). SC&A concludes that concrete liner effects should be considered to be negligible until demonstrated to be otherwise. Therefore, this model will not be considered here.

3.6 General Corrosion Model for the CRM Inner Barrier Without Drips

As discussed, all of the WPDEE experts believe that the occurrence of drips will be very important to the degradation of waste packages and that drips will accelerate the corrosion processes. SC&A agrees that this is a major concern and, preferring to focus on the more worrisome or worse case scenarios, will not consider the model for the non-drip environment here.

3.7 General Corrosion Model for the CRM Inner Barrier in the Presence of Drips

Once the outer carbon steel barrier is penetrated, the inner Alloy 22 barrier will be exposed to the corrosive environment. SC&A expects the outer barrier to be first penetrated where drips impinge on the top of the WP. General corrosion rather than pitting of the steel is expected because the pH will be neutral to low (i.e., insignificant concrete buffering effect, as noted above). At the exposed patch of Alloy 22, galvanic protection afforded by the corroding steel will be negligible due to very limited throwing power of the current, according to the WPDEE experts (WPDEEe, Table 3-2). Potential corrosion of the inner barrier Alloy 22, which is a highly corrosion-resistant material, will depend on the local environmental conditions. These conditions have been much debated, and several scenarios for dripping water, based on the anticipated bulk environmental conditions and possible modifications due to a variety of mechanisms (concentration/saturation of J-13 water, oxidation of Fe^{2+} to Fe^{3+}, microbiologically influenced corrosion, etc.) have been developed by a consensus of the WPDEE experts (WPDEEe, p. 3-14). These environmental scenarios involve pH variations and electrochemical (i.e., oxidizing) potential levels, and they are listed here in Table 1. Conservative Alloy 22 corrosion rates for these environmental conditions are also shown in Table 1 (WPDEEe, Table 3-

3). In addition, estimated corrosion rates based on SC&A interpretation of the available data are also included. (Lawrence Livermore National Laboratory currently is conducting extensive, additional corrosion testing relating to the repository environment.)

Table 1. Alloy C-22 Corrosion Rates (μm/year)*

ENVIRONMENTAL SCENARIO	WPDEE TABLE 3-3 (WPDEEe)	SC&A ESTIMATE
Dripping Water (pH 3-10, E = 340 mv):		
1000X J-13 Water	3.75	1 (WPDEEe, Fig. 3-9a,)
Saturated J-13 Water	23.2	1 (the experts do not distinguish this condition from 1000X J-13 water)
Dripping Water (pH 2.5, E = 340 mv):		
1000X J-13 Water	5.8	25.4 (crevice conditions, HI88)**
Saturated J-13 Water	36	25.4 (crevice conditions, HI88)**
Dripping Water (pH 2.5, E = 640 mv):		
1000X J-13 Water	20	25.4 (crevice conditions, HI88)**
Saturated J-13 Water	36	25.4 (crevice conditions, HI88)**

* Conservative rates using 100 degrees C, 100% CDF, and no decay in corrosion current with time.

** Below 80° C crevice corrosion is assumed to cease (WPDEEe) and a 1 μm/year passive corrosion rate applies.

Dry oxidation and humid air corrosion will not play a significant role in metal loss on Alloy 22 because of the extremely low corrosion rates for these processes (WPDEEe). For general corrosion to occur on Alloy 22, all or most of the CAM corrosion products would have to be swept away from the Alloy 22 surface thereby precluding crevice corrosion conditions. It is possible that this will occur on some patches of the WP surface, in which case the corrosion rate should be low and correspond to the passive corrosion rates shown in Table 1 for the low potential (340 mv, pH 3-10 conditions (i.e., 1 μm/year in the opinion of SC&A). At this rate, it would take 20,000 years to penetrate the Alloy 22 barrier. However, along with others, SC&A believes that failure of the Alloy 22 when used as an inner barrier will occur not by general corrosion, but rather by more rapid localized corrosion caused by the creation of crevice corrosion conditions on the Alloy 22 surface after the carbon steel outer barrier has been penetrated (see the next paragraph).

3.8 Localized Corrosion Model for the CRM Inner Barrier

Alloy 22 is a relatively new material that possesses excellent general corrosion resistance to a variety of hostile chemical environments. However, it is susceptible to localized (pitting and crevice) corrosion in certain oxidizing environments. Formation of ferric ions due to oxidation of copious ferrous ions present from the corroding steel, coupled with the known presence of chlorides in the dripping water and salt buildups, can reasonably be expected to produce highly oxidizing $FeCl_3$ environments (NWTRB98: M. Streicher, p.112; J. Payer, p. 137; A. Saguez, p. 160). Such conditions may be present on the Alloy 22 surface under the CAM corrosion products and in the gap between the still intact CAM areas and the inner barrier. For the two acidic environments listed in Table 1, the SC&A-estimated corrosion rate value of 25.4 μm/year is taken from tests performed in boiling 10% $FeCl_3$ solution at Haynes International, Inc.(HI88). This rate may be an overly conservative (i.e., high) value and needs further research and testing. The rate is assumed to apply to Alloy 22 when Alloy 22 is the inner barrier in contact with carbon steel. Not all of the corrosion experts, notably D. Shoesmith (NWTRB98, pp. 160,161, and 166), agree that such aggressive corrosive conditions will exist as a result of crevice formation or the presence of $FeCl_3$, but they do not question the need for further information and research on this matter (NWTRB97a, see, e.g., J. Scully). Until this uncertainty is resolved by more research, SC&A believes the conservative approach adopted here is prudent. When the temperature falls below 80 degrees C, it is assumed that crevice corrosion will cease (WPDEEe; also NWTRB97a, discussion on pp. 172 - 173), and a passive corrosion rate of 1 μm/year will apply. Although this temperature threshold is probably overly conservative (i.e., too low) for Alloy 22, it is tentatively used here as a bounding case value. (Note from Fig. 1 that temperatures do not drop to this level until about 3500 years after closure of the repository.)

The consequence of applying a corrosion rate of 25.4 μm/year is penetration of the Alloy 22 inner barrier 787 years after the outer steel barrier is breached. Thus, the cumulative number of years from repository closure to entry of water into the base case design WP is the sum of the 2000 years before corrosion starts (see above) plus the 27 - 188 years required to corrode through 10 cm of carbon steel by aqueous corrosion, plus 787 years to corrode through the Alloy 22, or a total of 2814 to 2975 years after emplacement. These results compare fairly closely with the TSPA-VA value for the first breach of the WP, i.e., 2700 years (WPDMA, p.5-133), but the bulk of the TSPA-VA failures occur as a distribution ranging over times up to about one million years, a much more optimistic outcome. In practice, the VA waste package design would not significantly delay wall penetration, and it does not constitute an effective multi-barrier, defense-in-depth design.

4.0 DESIGN ALTERNATIVES

DOE is considering a number of design alternatives to the base case WP discussed above. Several of these designs (selected from DOERW298, Tables 8-2 and 8-5) will be considered here.

4.1 Two Corrosion-Resistant Materials

An example of this design is 2 cm of Alloy 22 outer barrier over 2 cm of titanium alloy inner barrier (or vice-versa). A passive corrosion rate of 1.0 μm/year (see above) can be assumed to apply when the Alloy 22 is on the outside of the WP. The corrosion resistance of the titanium alloy can reasonably be assumed to be the same, although this is somewhat of an oversimplification because the several Ti alloys that have been considered by DOE differ from Alloy 22 as well as from each other in their corrosion properties. Ti alloys may actually be superior to Alloy 22 in terms of passive corrosion rates and higher crevice corrosion temperatures, but they can be vulnerable to hydrogen absorption (hence embrittlement) and susceptible to attack by fluorides (NWTRB98, M.Streicher, p.221). (These are topics for further research in the DOE program.) Concerning Alloy 22/Ti permutations, any combination of these corrosion alloys either with themselves or with each other are not expected to lead to significant crevice corrosion, although the WPDEE experts recommend laboratory testing of this assumption (NWTRB98, pp. 226, 343, and 344). Calculating the expected life of this design, using the passive corrosion rate, 40,000 years of exposure to aqueous conditions (42,000 years after emplacement) would be required to breach the WP. However, use of this design would be significantly more expensive than the base case design.

4.2 Ceramic Coating

The DOE has proposed the application of a ceramic coating to the exterior of the WP to provide an impermeable barrier that would last a very long time in the repository environment. However, the WPDEE experts were skeptical that such a coating would be effective because it would be subject to cracking from handling, defects (porosity and cracks), thermal expansion, and mechanical loads such as rock falls (WPDEEe, p. 3-24). Any corrosion of the CAM under the ceramic coating would create voluminous corrosion products that would quickly cause spalling of the coating. SC&A believes that this design concept is not attractive.

4.3 Drip Shield and Backfill

The purpose of these barriers is to divert water away from the WP, and also, in the case of backfill, to provide protection from rockfall and seismic activity (DOERW298, p. 8-4). TSPA-VA sensitivity studies indicate that there are no significant differences in the overall WP failure profiles between the no-backfill and the backfill cases (WPDMA, p. 5-120). Backfill would likely eliminate the effect of free-fall velocity on the corrosion of the CAM, but, as calculated above, the difference in steel life would be only 161 years. Other possibly beneficial effects of using backfill, such as higher WP temperatures and mitigation of rockfall damage, have not yet been fully explored by DOE.

TSPA-VA sensitivity studies dealing with the use of a drip shield of Alloy 22 placed over the WP indicated that significant performance gains would result (WPDMA, p. 5-122). This is not unexpected, since, as calculated above, a 2 cm barrier of Alloy 22 corroding at a passive corrosion rate of 1 μm/year would provide 20,000 years of WP life before penetration could occur.

4.4 CRM over CAM over CRM Design

In this design, an outer barrier of Alloy 22 (2 cm thick) should provide 20,000 years before breach. The intermediate barrier of carbon steel (10 cm thick) should provide an additional 188 years (assuming no drip velocity effects). The final inner layer of Alloy 22 (2 cm) would corrode under passive conditions (because, from Fig. 1, the temperature would have fallen far below the crevice initiation level of 80 degrees C) to provide an additional 20,000 years of life. Thus, adding the initial dry period of 2000 years, the total time to breach this package would be 42,188 years after emplacement. However, this design would be a very expensive engineered barrier.

4.5 CRM over CAM Design

A variant of the preceding design, which the DOE has considered from time to time (although it is not mentioned in the TSPA-VA) is a 2 cm CRM barrier over the 10 cm CAM barrier. This design should provide 20,188 years (22,188 years after emplacement) before penetration. It is included here because of its reasonable performance (much superior to the base case design), lower cost (similar to that of the base case design) and complexity (compared to the triple barrier design), mechanical robustness (resistance to rockfall), and protection from corrosion-enhancing radiolysis effects on the WP surface. Lending support to this design, five of the six corrosion experts in the May 1998 NWTRB Workshop (NWTRB98) opposed using carbon steel on the outside of the waste package because of (a) high corrosion rates, (b) the possible creation of ferric ions, which would form a severe environment over the inner barrier, and (c) the risk of crushing the inner barrier by formation of steel corrosion products. Only D. Shoesmith continued to support use of steel on the outside of the WP, but even he admitted that spalling and wedging effects could be two problems associated with such a configuration.

4.6 Self-Shielded Design

A self-shielded WP can be designed by increasing the thickness of the CAM layer to 18 inches. DOE has considered such a design in the past (NWTRB96, H. Benton presentation). Using the above base case corrosion rates, the calculated time to penetration of this thickness of carbon steel is 122-858 years (2122-2858 years after emplacement), depending on the velocity effects of falling drips.

4.7 Thermal Loading

The DOE continues to examine repository designs involving several levels of thermal loading. Lower thermal loading accompanied by lower temperatures in the repository can be achieved by spreading the waste out over a wider area (DOERW298, p. 8-7) or by delaying emplacement for several decades. The USGS very recently recommended that a cool repository be considered to minimize impacts to the performance of the natural system (ACNW99, S. Brocoum presentation). One interesting consequence of lower temperatures could be enhanced performance of WP designs that employ Alloy 22, provided that the temperature levels are below the threshold for localized (pitting or crevice) corrosion to initiate on this alloy (e.g., 80 degrees C, as noted above). Performance of the CAM material could also be beneficially affected. DOE recognizes that lower thermal loading could be highly important to performance (DOERW298, p. 8-8) but it is unclear how much effort will be devoted to study of this repository design option.

4.8 Summary of Corrosion Calculations

Table 2 compares the penetration times calculated above for the various WP designs considered in this review. The TSPA-VA base case design (No. 1 in Table 2) provides less corrosion resistance than several of the alternate designs. Nearly an order of magnitude improvement in performance life (to over 22,000 years) can be obtained by shifting the Alloy 22 barrier from inside the steel barrier to the outside of the WP (i.e., Design No. 5). Designs employing two corrosion resistant materials (Nos. 2 and 3) would provide excellent performance (40,000 years of life before penetration), as would the triple barrier WP (No. 4), but all of these designs would be much more expensive to produce than Design No. 5. The fully shielded design (No. 6) provides the least protection of all designs listed because of the poor corrosion resistance of unprotected carbon steel.

Table 2. Summary of WP Design Performance

DESIGN		YEARS TO PENETRATION* (after repository closure)
1-	TSPA-VA: 10 cm A516 Carbon Steel (CS) over 2 cm Alloy 22	2814 -2975
2 -	2 cm Alloy 22 over 2 cm Ti	42,000
3 -	2 cm Ti over 2 cm Alloy 22	42,000
4 -	2 cm Alloy 22 over 10 cm CS over 2 cm Alloy 22	42,188
5 -	2 cm Alloy 22 over 10 cm CS	22,188
6 -	Shielded Design - 18" CS	2122 - 2858

*Penetration at top of WP (includes 2000 years for the period when T > 100°C and no significant corrosion occurs)

5.0 OTHER CONSIDERATIONS

5.1 Unresolved Uncertainties

As DOE readily admits, large uncertainties remain for critical factors affecting WP performance, such as environmental conditions surrounding the WPs and long-term corrosion rates for the materials used in the WPs (TSPA98, p. 3-79; DOERW498, pp. 2-3 to 2-5). In addition, several other factors which may be important have been discussed in the TSPA-VA (TSPA98, p. 3-84; WPDMA, p. 5-137; DOERW298, p. 8-29) but they have not been fully dealt with, either because of a lack of available data or because they have not been assigned a sufficiently high priority in the program. These include stress corrosion cracking, microbiologically influenced corrosion, radiolysis-induced corrosion, metallurgical phase stability, residual moisture inside the container, fabrication viability, welding effects, susceptibility to hydrogen embrittlement, interaction with pedestal materials, and, to some extent, juvenile WP failures and variability/uncertainty characteristics of performance factors. Additional data and analyses are needed to reduce uncertainties associated with these factors, and, accordingly, the DOE has an extensive laboratory test program underway in pursuit of these needs.

5.2 Transparency of TSPA-VA

The NWTRB has stressed the need for ease of understanding the process by which studies, assumptions, and analyses lead to the results of any given document (NWTRB97b). This is also stated as a goal in the TSPA-VA (TSPA98, p. 2-3). It is arguable that such transparency has not been achieved either in the TSPA-VA or in the supporting technical document (WPDMA) because it is not readily apparent to the reader how some of the final results and conclusions were reached. This may be an unfair conclusion in view of the sheer volume and complexity of the information included in the documents. Nevertheless, the implementation of the mathematical models into the computer codes is, in general, very vague and not explained, and the implication is always present that the reader should simply accept the results of the computer calculations. For example (TSPA98, p. 3-85), juvenile failures and degradation by corrosion processes are said to be incorporated into a computer code that is based on a probabilistic approach; the logic flow for the degradation model is shown (TSPA98, Fig. 3-44) and environmental parameters are briefly discussed, but no detailed modeling calculations are provided. Another example is the missing explanation as to how high-temperature data for distilled water corrosion of carbon steel was "scaled" to reflect performance in natural waters in the development of the general corrosion model for this material (WPDMA, p. 5-39).

6.0 CONCLUSIONS

- This review reveals inadequacies in the TSPA calculations of the corrosion performance of the CAM outer barrier and the CRM inner barrier of the base case WP design. The effects of free-falling drip velocity, salt deposits, and corrosion product spalling are not taken into account for the CAM performance, and treatment of the CRM inner barrier corrosion does not adequately account for the likely establishment of an aggressive environment in the crevice formed at the CRM surface under dripping conditions.

- In this review, the limited corrosion data available were interpreted and used together with conservative assumptions to recalculate base case WP design performance under dripping conditions. The resulting time to first breach of the WP was calculated as 2814 - 2975 years. In contrast, the TSPA-VA appears to be overly optimistic: a value of 2700 years is given for the initial breaching of a WP, but the bulk of the failures were distributed over times ranging out to about one million years. The DOE "defense in depth" strategy of employing two barrier materials subject to different degradation mechanisms to offset uncertainties appears to be faulty if one of the materials (i.e., carbon steel) offers little protection.

- Although the DOE TSPA-VA base case design appears to provide inadequate performance, several alternate designs discussed in the TSPA-VA possess characteristics indicating that the regulatory requirements can be met, even when very conservative, upper bounding corrosion rates are assumed. Nearly an order of magnitude improvement in performance life (to over 22,000 years) can be obtained by shifting the Alloy 22 barrier from inside the steel barrier to the outside of the WP. The reason for this is the excellent corrosion resistance of Alloy 22 when it is corroded by a general corrosion mechanism as opposed to much higher (25X) rates when it corrodes by oxidizing, crevice corrosion conditions under the carbon steel CAM. Other, more expensive designs were calculated to provide over 42,000 years of resistance to penetration.

- The use of backfill does not appear to improve WP performance significantly. In contrast, installation of an Alloy 22 drip shield would contribute substantially to increased WP corrosion life, although such a drip shield may not be necessary if Alloy 22 is used as a barrier on the outside of the WP.

- DOE recognizes that large uncertainties remain in the area of WP degradation, which the NRC considers to be the most important issue in the total system performance of the repository. The extensive DOE test program now underway to address this problem should strongly contribute to resolving the uncertainties of barrier materials performance.

- The TSPA-VA goal to produce a transparent document has not been achieved, in that it is not readily apparent to the reader how most of the final results and conclusions were reached. Implementation of the mathematical models into the computer codes is, in general, very vague and not explained, and the implication is that the reader should simply accept the results of the computer calculations.

7.0 REFERENCES

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APPENDIX C

MODELING OF WASTE FORM PERFORMANCE IN THE TSPA-VA

MODELING OF WASTE FORM PERFORMANCE IN THE TSPA-VA

1. INTRODUCTION

For purposes of this review, waste form performance involves all of the performance factors relevant to radionuclide release from a waste package after the wall of the package has been penetrated. This discussion focuses on commercial spent nuclear fuel (CSNF), which dominates the potential for radioactivity release from the VA-design repository because of the large number of packages of this waste type (7,642) expected to be in the repository in comparison with the number of packages of defense wastes (2,858) , and because of the large radioactivity inventory per CSNF package in comparison with defense-waste-package inventories.

The relevant performance factors include degradation of the CSNF cladding, which determines the exposed waste form area in a package, rate of radionuclide release from exposed spent fuel, in-package dilution of the concentration of released radionuclides, and the time and rate of release of radionuclides from the package interior to the near field. Each of these performance factors is discussed below. The TSPA-VA used a simplified representation of these processes in which in-package dilution and in-package transit time were omitted from the models. The potential for contribution of these factors to repository system performance was recognized and discussed in the TSPA-VA documentation, but they were omitted from the TSPA-VA analyses because of uncertainties in how to assign values to the performance parameters.

As shown in Figure 2-13 of Volume 3 of the VA report (DOE 1998a) the CLAD_DEG model is used to model cladding degradation except for long-term corrosion of the Zircaloy[1] cladding which is modeled with WAPDEG - the waste package degradation model. Waste form degradation, rate of radionuclide release from the waste form, in-package dilution of the released radionuclides and rate of radionuclide exit from the waste package and through the EBS are modeled with the RIP code. The sensitivity of the base case results to secondary phases which control the release rate for neptunium is modeled using the reaction transport model code AREST-CT. It is important to note that only minimal descriptions of computer codes are included in the TSPA-VA and the Technical Basis Document. No information is included on the quality assurance of the codes. In addition, neither of these documents contains a focused

[1] Unless otherwise specified Zircaloy means either Zircaloy-2 or Zircaloy-4. Zircaloy-2 is typically used as the cladding in BWRs while Zircaloy-4 is the cladding typically used in PWRs.

summary of the input parameters to each code, the basis for parameter selection, and quality assurance related to input parameters.

2. EXPOSED WASTE FORM AREA IN PENETRATED PACKAGES

Commercial spent nuclear fuel (CSNF) is the major waste component designated for disposal at Yucca Mountain. CSNF, which comprises 63,000 MTHM or about 90% of the total waste, is primarily fuel assemblies from BWR and PWR reactors (Volume 3, p. 3-95). A small fraction of these assemblies are clad with stainless steel, but the majority are clad with zirconium alloys (Zircaloy-2 and Zircaloy-4). Some of the fuel assemblies will have defects present at the time of disposal. Some assemblies may develop cladding defects after disposal, but before waste package breach, by processes such as creep rupture. Other assemblies may develop cladding defects after waste package breach by processes such as aqueous corrosion. These failures will expose some of the spent fuel (uranium dioxide) to water. The water can leach various radionuclides from the spent fuel and cause the nuclides to become mobilized and available for transport out of the waste package and through the engineered barrier structure. The area of the exposed waste form is a key performance factor in assessing radionuclide release from failed waste packages. The greater the exposed waste form area, the greater will be the radionuclide release.

In the TSPA-VA it is assumed that all stainless steel-clad fuel rods have failed by the time of disposal. These stainless steel rods comprise about 1.15% of the total fuel rod inventory. It is further assumed that 0.1% of the Zircaloy-clad fuel rods have also failed prior to emplacement. Thus, a total of 1.25% of the fuel rods are assumed to have failed at initial emplacement (Volume 3, Section 3.5.2.1). For modeling purposes, this fuel is assumed to be totally exposed at the time of waste package breach; no cladding is assumed to be present, even though most of the failures will be hairline cracks or pinholes (EPRI 1997).

As time passes Zircaloy-clad fuel rods in breached waste packages are assumed to corrode, and eventually additional rods will fail, exposing more spent fuel. Mechanical failures are also modeled in which rocks from the drift wall fall onto the waste packages. When the waste packages have lost their structural integrity due to corrosion, rocks falling onto the fuel assemblies are assumed to shear some of the fuel pins and expose more fuel.

The TSPA-VA also considered creep rupture, delayed hydride cracking, hydrogen embrittlement, cladding oxidation, and cladding splitting (unzipping) due to fuel oxidation and swelling. However, none of these processes was included in the cladding degradation abstraction. Neither creep rupture nor delayed hydride cracking contributed significantly to the amount of fuel available for dissolution (Volume 3, p. 3-100). It was noted that creep could occur in the early stages of post-closure if the temperature and the attendant hoop stresses in the cladding were high enough. However, the temperature is not sufficiently high in the average waste package for creep failures to occur. Hydride embrittlement was also discounted based on the assumption that the cladding would pick up less than an additional 50 ppm of hydrogen from corrosion after waste package breach, and this amount of additional hydrogen was expected to have a negligible effect on the fracture toughness of the Zircaloy (Volume 3, p. 3-100). This conclusion was based on the experimental work of Kreyns et al. (1996). DOE calculated hydrogen pickup for the peak pin in the average waste package and in the design (hot) waste package as a function of time after waste package failure (Chapter 6, Table 6-15). If the waste package failed at 1,000 years (by a juvenile failure mechanism), the hydrogen pickup for the center pin was 4 ppm in the average WP and 41 ppm in the design WP.

2.1 Modeling of Exposed CSNF Area in the TSPA-VA

The exposed fuel area as a function of time is developed with the computer code CLAD_DEG. The output from this code, the fraction of fuel exposed for dissolution (A_{fuel}), is one of the input parameters to the RIP computer code which models waste form degradation and EBS transport (Volume 3, Figure 2-13). Modeling is discussed in Volume 3, Section 3.5 of the Total System Performance Assessment and in Chapter 6 of the Technical Basis Document. Long-term corrosion of the Zircaloy was modeled with the waste package degradation code (WAPDEG).

The elements contained in the base case for modeling cladding degradation included the fraction of rods failed at emplacement, the fraction of rods that fail by creep, the fraction of rods that fail due to corrosion, and the fraction of rods that fail due to breakage from rock falls. The fraction of rods failed at emplacement was a time-independent value of 1.25%. Since the contribution of creep to total releases is very small, pre-emplacement failures are the only significant release mechanism for the first 60,000 years. Corrosion and mechanical failure mechanisms begin to contribute to releases after that time, although not all of the waste packages will have failed in one million years. The expected values for long-term mechanical failure are 0.18% in 100,000 years after WP breach and 2.62% in one million years after WP breach. Similarly, the expected values for Zircaloy corrosion failures are 1.51% and 7.75% for 100,000 and one million years after WP breach, respectively (Volume 3, p. 4-12).

In the TSPA-VA, both upper and lower limits for fuel exposure from Zircaloy corrosion and mechanical failure are developed. The RIP computer program samples between these limits for each Monte Carlo realization assuming a log-uniform distribution between the limits.

The Zircaloy corrosion model was based on the Alloy 22 general corrosion model for the waste packages as implemented in the WAPDEG computer code. The WP model was modified by assuming that the minimum Zircaloy corrosion rate was a factor of 1,000 greater than for Alloy 22 and the maximum corrosion rate was a factor of 10 greater than for Alloy 22. Corrosion failure of the Zircaloy cladding was assumed to occur when the thickness of a patch, which for Zircaloy cladding was defined as an area of 10 sq. cm, was reduced 75%. The corrosion process begins when the waste package is breached, and the exposed fuel area as a function of time is based on the number of failed cladding patches (Volume 3, p. 3-102).

2.2 Relevant Data

All of the cladding degradation processes are dependent on the temporal temperature distribution within the waste package. Temperature distributions were developed for the peak pin in the average waste package and in the design waste package as shown in Chapter 6, Figure 6-10.

Modeling of the resistance of the Zircaloy cladding to creep failure requires numerous inputs, including the allowable creep strain, the cladding hoop stress, the temporal temperature dependance of the cladding, and an appropriate creep equation which defines the functional dependence of strain on time, temperature, and stress. The cladding hoop stress depends on the thickness and diameter of the Zircaloy cladding and on the internal pressure within the fuel pin. The cladding diameter is a function of fuel element design. The cladding thickness is also a function of fuel element design but additionally depends on the amount of cladding thickness reduction attributable to oxidation and the extent to which wall-thinning flaws (cracks) were introduced during manufacture and reactor service. The internal pressure in the fuel pin is determined by the initial pressure of He fill gas, the fission gas release, and the time-varying gas temperature. Fission gas release is a function of fuel burnup.

In the TSPA-VA, DOE selected a Westinghouse W1717WL (17 x 17 Lopar) PWR fuel assembly for modeling of cladding creep. This type of assembly was chosen because it is the most commonly used PWR fuel assembly design and has the thinnest cladding (Chapter 6, p. 6-21). Since PWR assemblies operate at higher stress and have thinner cladding than BWR assemblies, use of PWR assemblies in the TSPA-VA analyses is a conservative approach. The Zircaloy fuel pins have a cladding thickness of 0.057 cm, and an initial fill pressure of 2.8 MPa (Chapter 6, Table 6-8). DOE developed an empirical equation for fission gas release as a function of burnup based on data compiled by Manzel and Coquerelle (1997).

These authors measured the fission gas release from Zr-clad PWR fuel rods irradiated in a commercial reactor to burnups ranging from 30 to 80 MWd/kgU. Average linear heat generation rates varied from 270 to 310 W/cm for the first irradiation cycle to 130 to 160 W/cm for the seventh cycle. At a burn up of 60,000 MWd/MTU, the empirical equation indicated that the fractional fission gas release would be 9.86% (Chapter 6, Table 6-9). In calculating the tensile (hoop) stress in the cladding, the nominal thickness was reduced by the amount of the cladding that was converted to an oxide film during reactor service to various burnup levels (Chapter 6, p. 6-21).

This calculation showed that the cladding is reduced in thickness from its initial value of 0.057 cm to 0.049 cm at a burnup of 60 MWd/kgU (Chapter 6, Table 6-14). DOE also developed a probability distribution for manufacturing defects assuming an exponential distribution and concluded that the median crack depth was 12 μm and the maximum crack depth was 160 μm. The probability that the maximum depth crack would occur in a fuel pin is 0.00015 (Chapter 6, p. 6-24). The amount of strain in the center fuel pin in the design WP was calculated by SC&A for various combinations of crack depth and burn up (extracted from Table 6-14 in Chapter 6) for the first 100 years after disposal. The results in summary are:

- For a burnup of 40 MWd/kgU and a median crack stress of 31.8 MPa, the total creep strain is 0.32%
- For a burnup of 40 MWd/kgU and a maximum crack stress of 43.2 MPa, the total creep strain is 0.45%
- For a burnup of 60 MWd/kgU and a median crack stress of 48.4 MPa, the total creep strain is 0.51%

- For a burnup of 60 MWd/kgU and a maximum crack strain of 65.8 MPa, the total creep strain is 0.72%

The calculations were limited to 100 years because strain accumulations beyond that time are very small. In no case did the cumulative strain exceed a limit of 1%, which various researchers have suggested as a reasonable value.

DOE evaluated several creep models and data sets in the TSPA-VA (Chapter 6, p. 6-35 and Table 6-17) and selected the creep equations developed by Matsuo (1987). These equations were selected because the variance of several sets of experimental data from the Matsuo creep model was half that obtained with a similar model developed by Mayazumi and Onchi (1990). However, the Mayazumi and Onchi model predicts somewhat higher creep strains than does the Matsuo model. The cumulative strains over 100 years for each model at various stress levels derived from the specific burnups and crack depths described in the preceding paragraph are compared in Table 1.

Table 1. Cumulative Cladding Strains after 100 years as Predicted by Different Creep Models for the Center Fuel Pin in the Design WP

	Creep Strain at 100 years (%)	
Stress at 27°C (MPa)	**Matsuo Model**	**Mayazumi & Onchi Model**
31.8	0.32	0.55
43.2	0.45	1.06
48.4	0.51	1.42
65.8	0.72	3.83

Although it is not clear how many additional fuel pins would fail based on the more conservative Mayazumi and Onchi creep model, the number should not be large because of the following factors:

- The calculations are based on the temperature distribution for the design waste package, not the average waste package
- The higher stresses (>40 MPa at 27°C) are associated either with the maximum crack depth (with a 0.00015 occurrence probability) or with burnups exceeding 50

MWd/kgU as compared to an average expected burnup of 40 MWd/kgU for CSNF

In the TSPA-VA, DOE cites EPRI 1997 as the source of information on Zircaloy cladding failures, noting that the average pin failure rate is 0.01 to 0.05%. Thus, the selection of 0.1% appears conservative. SC&A independently assessed available failure data and stated that 0.1% was an appropriate upper limit for Zircaloy-clad fuel (SCA 1998). The TSPA-VA assumes that all the stainless steel-clad pins have failed at the time of emplacement. In an separate study, SC&A concluded that only about 840 of a total of 397,048 stainless-steel clad pins have actually failed (SCA 1998). Assuming that the general corrosion rate for stainless steel in tuff water at 105°C is 0.3 μm/yr (EPRI 1996), then the stainless steel cladding will have lost half its thickness in 500 to 1750 years after waste package breach, depending on the specific fuel element design. The approach taken by DOE in the TSPA-VA for the stainless steel cladding is bounding.

The TSPA-VA assumes that, upon WP failure, all the fuel is immediately exposed in the pins with pre-emplacement failures. An EPRI study has reported that 80 to 90% of the failed fuel pins have pinholes or hairline cracks, 0 to 20% are in an intermediate condition, and less than 1% have severe damage (EPRI 1997). Thus, the assumption that all of the fuel in the failed pins is exposed is clearly conservative.

2.3 Data Uncertainties

Most cladding degradation processes are highly sensitive to temperature. Calculating the temperature distribution within a waste package is a complex heat transfer problem leading to substantial uncertainties. In the TSPA-VA, DOE calculated the time-varying center fuel pin temperature for a design base (hot) waste package and an average waste package. The peak center pin temperature in the design waste package is about 327°C and in the average waste package is about 245°C.

After 1,000 years, when a juvenile waste package failure is projected to occur, the center fuel pin in the design base waste package has fallen to about 140°C while the center fuel pin in the average waste package has fallen to about 100°C. The uncertainty associated with these values is unknown. The TSPA Peer Review Panel noted that debris from rock falls can increase the waste package temperature (PRP 1999). The panel asserted that, depending on the timing and extent of such rock falls, the waste package temperature could exceed 350°C and cause unanticipated cladding failures. DOE needs to provide an appropriate thermal analysis to show whether this is a problem and adjust the fuel rod cladding failure level if necessary.

Data on the number of fuel rod failures prior to emplacement are based either on conservative (Zircaloy-clad) or bounding (stainless steel-clad) assumptions.

Data on the general corrosion of Zircaloy under repository conditions are highly uncertain. In the TSPA-VA, corrosion failures were estimated based on the assumption that the Zircaloy was between 10 and 1,000 times more corrosion resistant than Alloy 22 which forms the inner liner of the waste packages. In order to use the WAPDEG code for calculating Zircaloy corrosion, it is necessary to know the comparative corrosion rates of Zircaloy and the nickel-base Alloy C-22 under similar conditions. Such data are not currently available. However, data are available on a similar nickel alloy (Alloy C-276) and a similar zirconium alloy (Zircaloy 702) but only for exposure to hot, concentrated mineral acids. Under these conditions, the Zircaloy 702 was between 10 and 80,000 times more resistant than the C-276 (Chapter 6, p. 6-34).

This obviously is a questionable extrapolation and a major source of long-term uncertainty. Although not used in the Zircaloy corrosion model, data are included in Chapter 6 describing the corrosion rate of Zircaloy in water based on corrosion tests of up to thirty years duration conducted by the Bettis Atomic Power Laboratory. At 100°C, the corrosion rate, based on the Bettis data, is the same as that based on the assumption that the Zircaloy corrosion rate is 1/1000 that of Alloy 22. At lower temperatures the Bettis data predict lower rates than the Alloy 22 correlation (Chapter 6, Figure 6-12). Thus, even though the extrapolations used in the TSPA-VA are questionable, they appear to be conservative. The fraction of patches that have failed in 10,000 years <u>after</u> waste package breach is about $7x10^{-3}$ for the highest corrosion rate (Chapter 6, Figure 6-13) and very few waste packages are breached in less than 10,000 years. Consequently, the contribution of exposed fuel from Zircaloy corrosion during the expected 10,000-year regulatory period is very small, even when considering the uncertainty in the corrosion rate data.

In a recent presentation to the Nuclear Waste Technical Review Board, DOE provided a caveat on its corrosion analysis noting that "localized mechanisms and chemical conditions within the waste package are not well understood and introduce significant uncertainty" (DOE 1999).

2.4 Potential to Reduce Data Uncertainties

Since the numbers of pre-emplacement fuel rod failures are based on conservative or bounding assumptions, the data are not treated as uncertain parameters in performance assessment.

As noted there is considerable spread in the Zircaloy corrosion rate data used to calculate long-term general corrosion but the data used appear to be conservative and the process is not significant over a 10,000-year regulatory time frame. The modeling of long-term mechanical failures from rock falls requires refinement and peer review. Open issues relating to hydride reorientation and embrittlement are not resolved. Further model development coupled with laboratory experiments and continued gathering of industry data can help to reduce uncertainties associated with these processes and, thereby, reduce uncertainty in the amount of fuel exposed as a function of time.

2.5 Modeling and Abstraction Uncertainties

SC&A independently modeled cladding oxidation, creep rupture, and delayed hydride cracking (SCA 1998). Assuming that the center pin temperature in the design WP is about 140°C when a juvenile waste package breach occurs at 1000 years (Chapter 6, Figure 6-10), the SC&A analysis indicates that more than one million years would be required to oxidize 25% of the cladding thickness even if the temperature did not decrease any further. Consistent with this, Equation 6-8 in Chapter 6 would predict that the oxide film formed after one million years is negligible. SC&A modeled delayed hydride cracking and showed that the stress concentration, after one million years at a temperatures exceeding the maximum center pin temperature in the design waste package (350°C versus 327°C for the design WP), was well below a critical stress concentration of 10 MPa•$m^{0.5}$ for crack propagation. Consistent with this conclusion, DOE noted in the TSPA-VA that stress intensity factors are too low to facilitate crack propagation and, consequently, delayed hydride cracking was not included in the abstraction for the RIP analysis (Chapter 6, p. 6-40). SC&A determined that the creep strain at a stress of 80 MPa[2] and a temperature of 325°C for 20 years was about 1.1%, based on the conservative creep equations (i.e , those producing the highest creep strains) developed by Mayazumi and Onchi (1990). A creep strain of about 1% is a commonly accepted limit for Zircaloy cladding (SCA 1998). As

[2] This stress did not take into account clad thinning from surface oxidation or possible manufacturing defects so is non-conservative: it did, however, assume 20% fission gas release which is conservative.

shown in Chapter 6, Figure 6-11, the center fuel pin temperature in the design WP will have fallen to less than 300°C after 20 years. These independent calculations support the position taken by DOE in the TSPA-VA that creep failures of the Zircaloy cladding do not contribute significantly to the source term (Volume 3, p. 3-1-1). Creep failure is not included in the RIP abstraction (Chapter 6, p. 6-36).

The TSPA-VA cladding degradation abstraction contains two new elements that need careful review and validation before preparation of the TSPA-LA. These are the model for cladding corrosion and the model for mechanical failures due to rock falls. Within a likely 10,000-year regulatory horizon, these potential failure modes are not expected to have any impact, but they become increasingly important for longer times.

Based on the assumption that hydrogen pickup after disposal is small, the TSPA-VA abstraction did not consider hydrogen embrittlement. The possibility requires more study. The extent of hydride reorientation into the radial direction and hydrogen concentration by diffusion down any thermal gradients need to be more rigorously examined. The TSPA Peer Review Panel stated that this failure possibility was not adequately addressed in the TSPA-VA and, consequently, "the extent of the credit taken for cladding in the analysis is questioned" (PRP 1999).

It its Issue Resolution Status Report on container life and source term dated November 1998, NRC commented on the importance of various potential cladding failure mechanisms (NRC 1998). This status report was issued prior to publication of the TSPA-VA by DOE but certainly reflected some of the results to be included in the TSPA-VA. NRC stated that:

- DOE needs to consider localized corrosion (pitting) of Zircaloy and the possibility of stress corrosion cracking in oxidizing chloride solutions.

- There is a general consensus that creep cladding failure is unlikely under repository conditions assuming no backfill. Nevertheless, DOE needs to resolve certain discrepancies regarding process mechanics and parameters and assess the potential for creep failure with alternative EBS designs.

- Delayed hydride cracking is not expected to be important under repository conditions, but the supporting arguments could be strengthened by quantifying crack size distribution in the cladding. (This was done in the TSPA-VA.)

- Hydrogen embrittlement may or may not be an important failure mechanism, depending on the cladding temperature which dictates the extent to which hydrides can reorient into the undesirable radial mode. (This reorientation can occur in regions where the cladding temperature exceeds 300°C.)

- Cladding oxidation is not a viable failure mechanism if the drifts are not backfilled.

- DOE has in place an appropriate experimental program to determine whether UO_2 oxidation and swelling could cause the cladding to split.

- The modeling of mechanical failures because of rock falls requires substantial refinement.

- The main issue that needs to be resolved is the temperature of the cladding since this drives most potential failure mechanisms.

The TSPA-VA base case did not consider use of backfill. Use of backfill would generally increase cladding temperatures and probably foster failure mechanisms not active in the absense of backfill.

2.6 Performance Factor Uncertainties

When examining the uncertainty and sensitivity analyses in the TSPA-VA, it is important to note that those parameters shown to be significant are based on the specific modeling assumptions in the performance assessment. With alternative modeling assumptions parameter significance might change.

Sensitivity analyses show that none of the uncertain parameters related to this performance factor are among those primarily responsible for the uncertainty in the peak dose rates (Volume 3, Figure 4-34). Although not having a significant effect on dose rate uncertainty, uncertainty in the number of cladding failures due to Zircaloy corrosion is second in importance in characterizing uncertainty in release from the engineered barrier system after one million years (Volume 3, Table 4-1).

Additional sensitivity analyses were conducted in which the expected value case for fractional cladding failures was compared with results where the factor was held at its 5th and its 95th percentile values. After both 1,000 and 100,000 years, the dose rate (mrem/yr) is essentially the same for the expected value, 5th percentile, and 95th percentile cases. This is because the only contributor to the exposed fuel area during these periods is those rods that have failed at the time of emplacement. It is only during the period from 100,000 to one million years that Zircaloy corrosion and mechanical failure mechanisms come into play and some divergence between the three probability distributions appears. The spread in the predicted dose rates between the 5th and the 95th percentiles is slightly over one order of magnitude at one million years due to changes in the cladding fraction failures (Volume 3, Figure 5-28).

DOE also considered alternative models for cladding failure as part of its sensitivity analyses. The alternate models included no cladding credit, total fuel exposure by 100,000 years and total fuel exposure by one million years. In the case of no cladding credit, the dose rate to individuals 20 km from the repository was about two orders of magnitude higher than for the base case after 10,000 years (i.e., 2 mrem/yr versus 0.04 mrem/yr) (Volume 3, Figure 5-29). This difference is attributed to increased releases of the radionuclide Tc-99. During the same period the other alternatives of total failure at 100,000 years and at one million years yield the same dose rates as the base case. This is because the both of these models assume 1% failure in 10,000 years. After the Tc-99 is exhausted, releases are dominated by solubility-limited neptunium. The no cladding credit case continues to show considerably higher releases than the base case through 100,000 years. At 250,000 years all four cases yield the same results and then begin to diverge.

Since DOE was concerned that uncertainties in the base case model might have been understated, the sensitivity of the results to another alternative model (in addition to those described above) was also examined. In this model the fractional cladding failures in a waste package are assumed to vary log-uniformly from 0.01 to 1.0 with a mean value of 0.215. Each quantity selected from this distribution during Monte Carlo sampling is assumed to have failed at the time the waste package is breached. Releases were examined at 10,000, 100,000 and one million years and, at each time, releases were higher with the alternative model.

At 10,000 years there is about a 15% probability that the peak dose rate will exceed 0.1 mrem/yr with the base case and about a 30% probability that the same peak dose rate will be exceeded with the alternative model (Volume 3, Figure 5-30). A step-wise regression analysis based on this alternative model shows that the cladding related parameters embedded in this performance factor, which emerge as important to the sensitivity of the releases, are the number of juvenile failures and the number of mechanical cladding failures after 10,000 years and the number of mechanical cladding failures after one million years (Volume 3, Figure 5-31). In the interim period after 100,000 years, the dominance of releases associated with solubility-limited Np precludes cladding failure as an important parameter.

DOE characterizes uncertainty in the integrity of the spent nuclear fuel cladding as having "high" significance for the first 10,000 years and having "medium" significance over the 100,000 year and one million year time frames (Volume 3, Table 6-1).

3.0 RATE OF RADIONUCLIDE RELEASE FROM THE EXPOSED WASTE FORM

3.1 Description of Performance Factor

Once the spent fuel is exposed to water through waste package and fuel cladding breach, the rate of radionuclide release depends on the dissolution rate of the waste form, the solubility constraints on radionuclide mobilization, and the extent to which colloids and secondary minerals form (Volume 3, p. 3-94). The dissolution rate for CSNF is calculated from a parametric equation based on experimental flow-rate data from spent fuel and UO_2. The experimental data provide non-equilibrium dependencies of the dissolution rate on pH, temperature, burnup, carbonate content, and oxygen potential in the parametric equation. The rate is expressed as the mass dissolved per unit area per unit time. The surface area is adjusted for fracturing of the fuel pellets and assumes some release contribution from the grain boundaries in the UO_2 pellets. DOE states that the parametric equation is not used in the TSPA-VA beyond the range of experimental values evaluated in its development (Volume 3, p. 3-103).

Dissolution rates for radionuclides from secondary phases were not included in the TSPA-VA base case but were examined in sensitivity analyses. When the spent fuel is contacted by ground water, a series of uranium minerals (including schoephite, uranophane, Na-boltwoodite, and soddyite) can form. The possibility exists that Np and other elements can be captured by these minerals so that their release rate would be governed by the dissolution rate of the secondary phase rather than that of the spent fuel (Volume 3, p. 3-106).

The model further provides that the solubility limits for each radionuclide of interest are not exceeded. Probability distributions for solubilities were established for each radionuclide based on experimental data, expert elicitations, and previous assessments (Volume 3, p. 3-99). If the solubility limit is exceeded in the modeling, the excess dissolved material is assumed to precipitate (Volume 3, p. 3-104).

Colloids are also considered in the model. Colloidal particles are particles small enough to become suspended and transported in the ground water. If the radionuclide concentration is solubility limited, formation of colloids can increase the rate of release from the waste package. Additionally, the rate of transport of colloids may be faster than that of the dissolved radionuclide which would also enhance release.

3.2 Use in TSPA-VA

The rate of radionuclide release from the exposed waste form establishes the source term used in the RIP code. In the base case, this rate is defined by a parametric equation which incorporates experimental data on pH, total carbonate, temperature, and oxygen fugacity. The temperature used is the average waste package temperature for each of the six regions modeled in the drift-scale, thermal hydrology model. DOE states that the use of the average waste package temperature is appropriate because differences between the waste package surface and the waste package internals will be small at the time the waste package fails (Volume 3, p. 4-13).

Although many types of colloids are expected to be present at Yucca Mountain, only four types of colloids were included in the TSPA-VA modeling -- clay, iron-corrosion products, spent nuclear fuel colloids, and glass waste colloids (Volume 3, p. 3-100). The extent to which colloids contribute to release depends on such transport properties as velocity, filtration, sorption, and reversibility of the radionuclide attachment process. In the TSPA-VA, only Pu colloids were considered. Due to computer code limitations, it is not possible to model the full range of possible colloid behavior. Instead, the attachment of plutonium to colloids was treated either as a an instantaneously reversible process or as a completely irreversible process. This topic is treated in more detail below under the discussion of time and rate of radionuclide exit from waste package interior to the near field.

To address the possibility that neptunium release is controlled by its capture and dissolution by secondary uranium minerals, a reactive transport simulator was developed to calculate Np release rates. Simulations were conducted at two temperatures (30 and 70°C), two levels of cladding failure (1% and 11%), and two assumptions as to the uranium mineral phase from which the Np release occurred. Based on these simulations, the uranium concentration at the bottom of the waste package ranged from 1×10^{-9} to 1×10^{-6} mol/kg of solution. This modeling was not included in the base case but rather was examined in a separate sensitivity analysis.

3.3 Relevant Data

The dissolution rate equation was developed from measurements made on spent nuclear fuels over a range of controlled water chemistries and temperatures (Volume 3, p. 3-1-3).

Data on solubility limit distributions for key radionuclides are summarized in Table 3-15 of the TSPA (Volume 3). These distributions are based on a combination of expert elicitation, previous performance assessments, and experimental data. Except for Np, the solubilities are about the same as used in TSPA-1995 (Volume 3, p. 4-15).

Radionuclides residing in the gap between the fuel pellets and the cladding and a portion of the radionuclides at the UO_2 grain boundaries are assumed to be instantly released from failed fuel rods when the waste package is penetrated. This gap inventory is presented in Table 6-27 of Chapter 6 where the values for Cs-135, Tc-99, I-129, and Se-79 are assumed to be 2% of the total quantity of each species present at any time. A uniform distribution, varying from 1.25 to 5.75%, is assigned to C-14. EPRI (1998, p. 6-31) has assigned generally similar values (i.e., about a factor of 1.5 higher) for its best estimates except for Tc-99, which is a factor of 10 lower.

3.4 Data Uncertainties

The solubility limit distributions are wide, often spanning several orders of magnitude. For example, the technetium solubility spans seven orders of magnitude. Iodine, on the other hand, has a single value.

Comparison of the parametric dissolution rate regression equation with experimental data showed that the equation represented most experimental results within a factor of two and all 49 experimental points within an order of magnitude (Chapter 6, p. 6-66 and Figure 6-24). However, there is some question as to the appropriateness of assuming that the fuel matrix dissolution rate remains constant as was done in the TSPA-VA. EPRI (1998, p. 6-26) has noted experimental evidence suggesting that the dissolution rate is decreased by several orders of magnitude when alteration products are allowed to accumulate on the fuel matrix surface. Thus, the TSPA-VA assumption of a constant dissolution rate appears to be conservative if sufficient Ca and Si are present in the infiltrating water to form Ca-Si-U alteration phases.

3.5 Potential to Reduce Data Uncertainties

Significant potential exists to reduce uncertainties related to the role that colloids play in radionuclide release. Laboratory experiments should provide information on the behavior of other radionuclides besides Pu. Experiments are planned to address the extent to which the colloid attachment process is reversible. It is noteworthy that a substantial amount of experimental information was developed on colloid behavior for the WIPP project in 12 to 18 months leading to credible modeling of the importance of these particles in the WIPP repository performance assessment.

The range of solubilities for neptunium included in the TSPA-VA spans three orders of magnitude. About the same range was used in TSPA-1995, but the mean value is reduced by about three orders of magnitude in the TSPA-VA. Various other experimental measurements were excluded because they did not represent expected repository conditions. Since sensitivity studies show that base case dose rate results are no different than results obtained using 5th and 95th percentile values of Np solubility for the first 40,000 years (Volume 3, Figure 5-35), there appears to be little incentive to attempt to reduce the solubility range for Np based on an assumed 10,000-year regulatory time frame. However, Np solubility is an important factor contributing to uncertainty over longer times. According to EPRI 1998, an international body (the Nuclear Energy Agency) is currently conducting a review of thermodynamic data on neptunium which may indicate more conclusively the appropriate phases to use in solubility calculations (e.g., NpO_2 vs. Np_2O_5).

Technetium has a solubility range that spans more than seven orders of magnitude (Volume 3, Table 3-15). Based on a modified step-wise regression analysis where certain parameters important to dose rate sensitivity were fixed, technetium solubility was determined to be an important parameter in characterizing dose rate uncertainty (Volume 3, Figure 4-40). Additional experiments to reduce uncertainty in technicium solubility should be considered. The solubility ranges for other important elements (e.g., Pu, Am, and U) can probably be refined by continued review of available data, additional experiments, and improved modeling. For example, DOE has suggested that confidence in the solubility limits could be improved by using probability distributions that are specific to the chemistry of the water in contact with the waste form (Volume 3, p. 6-23).

The TSPA Peer Review Panel questioned the extensive reliance on expert elicitation in establishing solubility limit distributions (PRP 1999). In the panel's view, *"If there is any area amenable to experimental study, it should be the determination of concentration limits in relevant solution compositions."*

The data used in developing the parametric rate equation for radionuclide dissolution could probably be refined through the development of additional experimental data. However, as will be discussed subsequently, uncertainty in dose rates is not significantly altered by variations in dissolution rate given the specific modeling assumptions used in the TSPA-VA (Volume 3, Figure 5-32).

DOE did not include the possible retention of neptunium by secondary minerals in base case modeling. While this process was examined in sensitivity analyses and shown to reduce dose rates over a significant time period (i.e., 50,000 to 500,000 years), DOE concluded that additional laboratory and modeling work is required before the process can be considered for inclusion in the base case (Volume 3, p. 5-29). The studies should include the retention of other elements as well.

3.6 Modeling and Abstraction Uncertainties

Although fuel dissolution rates are potentially important parameters affecting uncertainty in releases of radionuclides to the environment, they did not emerge as important in the initial step-wise regression analysis. To further explore this issue, dose rates based on the 5th and 95th percentile dissolution rates were compared with the base case. Differences were indistinguishable for all times (Volume 3, Figure 5-32).

Base case modeling did not consider the possibility that Np could be captured by secondary phases after initial dissolution. However, this process, which has been demonstrated in laboratory experiments, was examined as part of the sensitivity analyses. For times less than about 50,000 years, results of including secondary phase retention of neptunium are no different than the base case because dose rates are dominated by technetium releases (Volume 3, Figure 5-33). Neptunium retention by secondary phases is significant over the longer term reducing dose rates by a factor of 25 as compared to the base case at about 200,000 years. The TSPA Peer Review Panel listed retention of radionuclides in spent fuel alteration products as one of the potentially conservative aspects of the TSPA-VA analysis (PRP 1999).

Diffusive transport out of failed fuel rods where the defect is a pin hole or a hairline crack is not modeled. Incorporation of this feature into the modeling would reduce release rates. (See discussion under Chapter 6, Section 6.6.1.4.)

3.7 Performance Factor Uncertainties

Sensitivity analyses show that none of the uncertain parameters related to this performance factor are among those primarily responsible for the uncertainty in the peak dose rates (Volume 3, Figure 4-34). However, it must be remembered that sensitivity analyses based on linear regression may show that, even though a particular parameter has a significant effect on the magnitude of the peak dose rate, the parameter may not be an important contributor to uncertainty if its uncertainty range is small. In order to provide greater transparency in addressing the uncertainty range for parameters, one can hold certain important parameters with large uncertainty ranges at their mean or median values and reexamine the sensitivities that may have been masked during the first sensitivity iteration. The TSPA-VA documents a secondary set of sensitivities obtained by holding the following parameters at their expected values:

- Infiltration rate and mountain-scale UZ flow
- Fraction of waste packages contacted by ground-water seepage and seepage flow rate
- Mean corrosion rate and variability of Alloy 22 in the waste package

Technetium solubility was established as one of the important parameters during the first 10,000 years in this secondary sensitivity analysis (Volume 3, Figure 4-40). Similarly, neptunium solubility was shown to be an important parameter contributing to uncertainty in the 100,000-year period (ibid.).

DOE characterizes uncertainty in neptunium solubility as having "low" significance over 10,000 years, as having medium significance over 100,000 years, and as having low significance over one million years. DOE characterizes the significance of uncertainty in spent fuel dissolution rate on peak doses to be the same as for neptunium solubility over the same time periods (Volume 3, Table 6-1).

The possibility that Np solubility can be affected by the presence of secondary uranium mineral phases can be of significance for the first 100,000 years, although this possibility was not included in the TSPA-VA base case.

4.0 IN-PACKAGE DILUTION OF CONCENTRATION OF RELEASED RADIONUCLIDES

4.1 Description of Performance Factor

Once a radionuclide has been solubilized or attached to a colloid at a site in the waste form, it must be transported by water within the waste package to a breach where it can exit the waste package. Depending on the amount of water in the waste package, the possibility of significant dilution exists.

4.2 Use in TSPA-VA

The waste package is assumed to be breached by corrosion processes which produce pits (with an area of 3.8×10^{-7} m^2) and patches (with an area of 0.031 m^2) (Chapter 6, p. 6-137). The advective flow into the WP through these openings is defined as qpatch and qpit. This water is assumed to immediately contact all the exposed waste. The water then exits the waste package via advective and diffusive flow through both patches and pits with no time delay. This modeling approach is highly conservative because it maximizes releases and increases releases at earlier times (Chapter 6, p. 6-132).

> *"The volume of water available for mobilization of waste at any time step (i.e., for computing solubility) is equal to the volume of water in the pores of the "rind," which is the growing shell of altered fuel being changed into other minerals through contact with gases and liquids that have entered the degraded waste package. This water volume is based on a porosity of 40 percent and a water saturation of 100 percent in the rind. The rind volume is linearly proportional to the fuel rod volume times the fuel dissolution rate (a constant with units of year^{-1}) times the time since first water contact"* (Volume 3, p. 4-15).

The rind volume is limited to the original fuel volume (Volume 3, p. 6-137).

4.3 Relevant Data

Relevant data include the extent of waste form alteration which is calculated from the fuel dissolution rate, the porosity of the converted waste form (assumed to be 40%), and the waste form saturation (assumed to be 100%)

Values of qpatch and qpit are obtained from the TOUGH2 and WAPDEG codes.

4.4 Data Uncertainties

A key issue is what fraction of the water flux dripping on the waste package actually enters the waste package interior once the package has been breached. While this has little effect on the Tc-99 releases from the EBS, it has a significant impact on Np-237 releases because of retardation effects. In the TSPA base case, DOE assumed that the amount of water entering the WP was proportional to the surface area of the breaches. In sensitivity studies, the base case assumption was compared with a case where all of the water dripping on the waste package was assumed to enter the interior. In this comparison, Np releases from the EBS were between three and four orders of magnitude different after 10,000 years (Chapter 6, Figure 6-68).

4.5 Potential to Reduce Data Uncertainties

Modifications to the EBS such as backfill or drip shields would reduce uncertainties regarding the amount of water entering a waste package.

4.6 Modeling and Abstraction Uncertainties

In the TSPA-VA model, any water that enters the waste package is assumed to contact the entire exposed waste form surface. The model assumes that water enters the WP at the top, traverses a 1.56 m path of exposed spent nuclear fuel and exits the bottom (Volume 3, p. 3-56). The TSPA-VA model does not take into account the fact that a drip entering the waste package at one end of a WP has a low probability of contacting the waste form at the other end of the WP. Nor does the model consider the time for radionuclides to diffuse along the thin film of water assumed to be lining the WP. Both of these omissions are conservative (Volume 3, p.6-16).

The TSPA Peer Review Panel stated that DOE needed to improve and make more realistic its description of the manner in which the waste package is damaged by corrosion (PRP 1999). This would involve the size and shape of the WP penetrations, the distribution of the penetrations in a WP, and the distribution of the penetrations across the entire WP inventory. Absent such a description of corrosion damage, it is not possible to model how in-package dilution occurs.

4.7 Performance Factor Uncertainties

There are substantial uncertainties associated with this performance factor. Although the model is simplistic it is probably conservative. The use of a bath tub model, as mentioned in the next section, would more closely approach the expected physical situation.

5.0 TIME AND RATE OF RADIONUCLIDE EXIT FROM PACKAGE INTERIOR TO THE NEAR FIELD

5.1 Description of Performance Factor

This performance factor is closely coupled to the previously discussed factor, In-Package Dilution of Concentration of Released Radionuclides. Either a moving stream of water or a film of water is required to transport radionuclides out of a failed waste package. If the waste package is in an area within the repository where water is dripping, water is potentially available to move through the waste package and provide advective transport. If water is not dripping directly on the waste package, a water film can nevertheless form which can support diffusive transport. Diffusive transport is much slower than advective transport.

5.2 Use in TSPA-VA

Transport through the engineered barrier system (EBS) is modeled in the RIP program using a series of three semi-circular mixing cells within the concrete invert underneath the waste package. Invert cells are coupled by advective and diffusive connections. The waste package is coupled to the first invert cell by an advective pathway representing water seepage from the waste package to the invert. The volumetric flux of water through the WP is obtained by scaling the seepage flux into the drift to the surface areas of patches and pits. The patch area available for seepage was probability adjusted from 1 to 10 (mean value 5.5) using a seepage collection factor to account for the focusing of water drips on the waste packages. The pit area was similarly adjusted using a factor of 0 to 2 (Chapter 6, p. 6-136). There are also two diffusive connections between the WP and invert to account for mass transfer from the pits and patches in the WP to the invert. The area of the pits and patches defines the area available for diffusion (Volume 3, p. 4-14).

The volumetric flux of water moving through the inverts is assumed to be the same as the seepage flux entering the drift. Sorption of some radionuclides in the invert is assumed by assigning probabilistic sorption coefficients (K_d values) to neptunium, protactinium, plutonium, and uranium. Technetium and iodine are not assumed to be retarded. Colloidal transport of plutonium is also modeled for four types of colloids[3]. The modeling assumes fast reversible attachment of Pu-239 and Pu-242 to the colloids (Volume 3, p. 4-15). A small fraction of the Pu (i.e., expected value of $1x10^{-7}$) is assumed to be irreversibly sorbed on the colloids.

Releases are calculated from each of six zones (areas) in the repository.

5.3 Relevant Data

Data required to model this performance factor include retardation coefficients for selected radionuclides, the aqueous colloid partitioning coefficient for Pu on various colloidal substrates, the fraction of Pu irreversibly attached to colloids, the volumetric flux of water through the waste package, the volumetric flux through the invert, and the invert porosity and saturation.

Other necessary data include the sizes of pits and patches in the waste package as a function of time, and the porosity and tortuosity of corrosion products in the pits.

5.4 Data Uncertainties

Radionuclide retardation in the concrete invert is modeled for plutonium, protactinium, uranium, and neptunium. Probability distribution functions are assigned to Kd values for each of these elements to reflect uncertainty in the sorption coefficients.

A fraction of plutonium irreversibly sorbed on colloids is assumed to range from $1x10^{-4}$ to $1x10^{-10}$ with an expected value of $1x10^{-7}$. The expected value was based on observation of

[3] The colloids include iron oxides, clays, and particles from spent nuclear fuel and waste glass.

colloidal-associated Pu with a concentration of 1×10^{-14} M downstream of a blast site at the Nevada Test Site. This observation, coupled with the expected solubility of 5×10^{-7} M for Pu, was the basis for the TSPA-VA assumption that the expected value for the fraction of Pu irreversibly sorbed was 1×10^{-7}. Since this value was highly uncertain, DOE assumed that the limits might lie as much as three orders of magnitude in either direction from the expected value (Volume 3, p. 3-106).

The seepage factor, which determines the flux of water into a breached waste package, was assumed to vary between 1 and 10 for patches and between 0 and 2 for pits in the container walls.

5.5 Potential to Reduce Data Uncertainties

This factor is modeled in a highly conservative manner in the TSPA-VA. A more realistic model would be a bathtub model in which the waste package must fill with water to the height of the breach before release can occur. The concentration of radionuclides exiting the WP would be substantially lower with a bathtub model. Since the seepage flux into a corrosion failed WP is 10^{-4} m^3/yr at 10,000 years (Volume 3, Figure 4-13), it would take about 30,000 years to fill a PWR waste package (with an assumed internal void volume of 40%) if the pits and patches were on the top of the WP. The fuel volume in a waste package is 1.112 m^3 (Chapter 6, Table 6-8). If this fuel is all converted to secondary minerals with 40% porosity (Volume 3, p. 4-15), the altered fuel would contain 0.44 m^3 of water. The water volume in the bathtub model could be as much as 3.56 m^3. Thus, the bath tub model could increase the dilution by factor of eight and delay the release by as much as 30,000 years.

As will be described below, uncertainty in this performance factor has little effect on dose rate uncertainty so there is little incentive to reduce the uncertainty underlying the K_d values.

As noted above, the TSPA-VA conservatively assumes that technetium and iodine dissolved in the ground water are not retarded. However, the TSPA-Peer Review Panel has questioned this assumption (PRP 1999). The panel observed that field observations near the failed Chernobyl reactor suggest iodine retardation. The panel suggested that DOE examine available field information on actual environmental migration.

5.6 Modeling and Abstraction Uncertainties

The fraction of plutonium colloids having irreversible sorption is one of four key variables contributing to uncertainty of releases from the EBS after one million years, but this variable did not have significant effect on dose rate 20 km downstream (Volume 3, Table 4-1). Sampling the irreversible fraction over a range spanning seven orders of magnitude showed "almost no effect on total dose" (Chapter 6, p. 6-104).

DOE has not yet addressed in detail the question of whether radionuclides other than Pu should be included in modeling the formation and transport of radionuclide-bearing colloids. It notes that, like plutonium, americium and thorium have low solubility and high sorption on host rocks. However, the inventories and half-lives of these species are shorter than those of Pu which makes it less likely that Am and Th colloids will contribute significantly to dose rates (Chapter 6, p. 6-97).

The concrete in the invert is assumed not to degrade but rather to retain the transport characteristics of concrete for all time periods included in the analysis (Volume 3, p. 3-109). While this assumption is questionable, sensitivity analyses included in the TSPA-VA suggest that transport through the invert does not have a significant impact on performance assessment.

Sorption on secondary uranium minerals and degraded basket and waste package materials is conservatively not included (Chapter 6, p.6-137). EPRI (1998) has shown that, for sorbing radionuclides such as Pu, Np, U, and Am, a 10-cm layer of corrosion products significantly reduces doses.

EPRI has suggested that "solid-solution substitution of trace radioelements into the dominant U-bearing alteration solid, rather than formation of separate compositionally pure solids for each radioelement is a more credible conceptual model for establishing solubility limits. Such an approach, revised for the specific situation at Yucca Mountain, would likely lead to defensible estimates for radioelement solubility limits that are several orders of magnitude lower than the values presented here." (EPRI 1998). DOE has, to some extent, considered this issue for Np only in the TSPA-VA (Chapter 6, Section 6.4.1.4).

5.7 Performance Factor Uncertainties

A modified stepwise linear regression analysis (see Section 2.5 above) showed that the seepage collection factor, used to characterize the extent to which drips are focused on the WP, is an important parameter contributing to the uncertainty in dose rates for both the 10,000- and 100,000-year periods (Volume 3, Figure 4-40). This parameter determines how much water enters the waste package and contacts the waste. Higher values of the parameter lead to higher releases for solubility-limited radionuclides.

Sensitivity studies summarized in Volume 3, Figure 5-35, show that uncertainty in the sorption coefficients used for to calculate retardation in the EBS is not a significant contributor to dose rate uncertainty. In these sensitivity studies, the dose rates based on the expected K_d values are compared with the dose rates for the 5th and 95th percentile K_d values. These analyses show that uncertainty in the K_d values has no effect for the first 35,000 years, since the dose rates are controlled by technetium which is not retarded. For intermediate times between 35,000 and 250,000 years where releases are driven by Np, the range in dose rate results is only a factor of two. For longer times, the cladding degradation dominates and so there is essentially no discernable contribution of K_d values to dose rate uncertainty (Volume 3, p. 5-31).

Another potential contributor to uncertainty in this performance factor is the uncertainty in the rate of formation and transport of radionuclide-bearing colloids. When the dose rate determined by the 95th percentile value of the K_c parameter (the aqueous colloid partitioning coefficient) is compared with dose rate based on the expected value of K_c, an effect can be discerned for the period between 50,000 and 250,000 years (Volume 3, Figure 5-36). The dose rate at 100,000 years is about a factor of six higher based on the 95th percentile values. The expected Kc value at one million years is 2.4, which means that the maximum mobilized concentration of Pu is 3.4 times the solubility limit (Chapter 6, p. 6-104).

DOE concludes that the significance on dose rate uncertainty of uncertainty in transport of radionuclides through and out of the engineered barrier system is "low" for all performance periods. DOE further concludes that the significance of uncertainty in the formation and transport of radionuclide-bearing colloids is "low" over 10,000 years, medium over 100,000 years and low over one million years (Volume 3, Table 6-1).

6.0 SUMMARY OF REVIEW FINDINGS

The fuel cladding provides a significant barrier to radionuclide release. Cladding reduces the dose rate at 10,000 years from about 2 mrem/yr with no cladding credit to about 0.04 mrem/y with TSPA-VA deterministic base case assumptions.[4] During this period, releases are driven primarily by the number of fuel rods that have failed at the time of emplacement. While this approach appears to be conservative, additional work is needed to show that hydride embrittlement of the Ziracloy will not contribute significantly to fuel pin failures and radionuclide releases during the first 10,000 years.

Technicium is the element of greatest interest for the first 10,000 years followed by iodine. The base case deterministic dose rate at 10,000 years is about 0.01 mrem/yr from iodine-129 and about 0.03 mrem/yr from technetium-99 (Volume 3, Figure 4-13). Technetium release from the waste package is the sum of advective and diffusive releases with advective releases from the waste package being about twenty times higher than diffusive releases at 10,000 years (ibid.).

The solubility of radionuclides is based on pure oxide end products. This assumption probably does not represent physical reality but appears to be conservative. Solubility limits should be refined based on expected water chemistry and reaction end members. Sorption of radionuclides on materials within the waste package, such as fuel alteration products and corrosion products was conservatively not included in the TSPA-VA. The extent to which such sorption might reduce transport out of the waste package should be examined.

The waste form dissolution rate was conservatively assumed to be constant in the TSPA-VA, although evidence exists suggesting that the buildup of alteration products on the surface of the waste form can reduce the dissolution rate by orders of magnitude. This issue requires further experimentation and analysis.

Colloidal-facilitated transport of plutonium colloids can contribute to peak doses over the 10,000 to 100,000 year time frame (Volume 3, p. 6-16). The expected Kc value for Pu is 2.0 at 100,000 years, which sets the maximum amount of mobilized Pu at three times the solubility limit

[4] Based on a probabilistic approach to performance assessment, the median peak dose rate is 0.002 mrem/yr with the range between the 5th and 95th percentile being 0 to 0.8 mrem/yr. The mean peak dose rate is 0.1 mrem/yr. With no cladding credit, the median peak dose would be about 1 mrem/yr (Volume 3, p. 6-7).

(Chapter 6, p. 6-104). The role of other radionuclides in colloid transport needs to be examined, although DOE suggests that results for Pu are probably bounding.

6.1 Key Simplifications and Assumptions Used to Produce the TSPA-VA Results

Significant simplifications are made in the TSPA-VA as to how radionuclides are mobilized and transported out of failed waste packages. For example, the TSPA-VA assumed that once a fuel pin has failed the entire fuel area is exposed to water entering the waste package. In addition, a flow-through model rather than a bathtub model is used to characterize dilution within the failed waste packages.

6.2 Uncertainties in TSPA-VA Results and Principal Sources of Uncertainity

The principal source of uncertainty related to these performance factors for the first 10,000 years is technetium solubility. A probability distribution spanning seven orders of magnitude is assigned to this parameter (Volume 3, Table 3-15). Another significant source of uncertainty is the fraction of the seepage which contacts the waste forms.

6.3 Assessment of the TSPA-VA Sensitivity Evaluations

The sensitivity studies in the TSPA-VA are extensive. They adequately characterize the major factors contributing to uncertainty in releases from the EBS and doses to the downstream individuals. They indicate where future effort can be most profitably allocated to reduce dose and uncertainty in dose. The dose rates are very sensitive to whether or not credit is taken for the Zircaloy cladding as noted above.

6.4 Performance Allocations

The most significant components effecting the dose rate at 20 km from the site for the first 10,000 years are (Volume 3, p. 6-7):

- Seepage contacting the waste forms
- Rate of cladding failure

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APPENDIX D

MODELING OF THERMAL HYDROLOGY IN THE TSPA-VA

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MODELING OF THERMAL HYDROLOGY IN THE TSPA-VA

Thermal hydrology models calculate temperatures (waste package surface, waste form, drift wall) and relative humidities to provide information needed for other models such as the waste-package degradation model and the near field geochemical environment models. The values calculated for the parameters (e.g., the drift wall temperature) will depend on design choices such as the thermal load on the geology that results from the waste package emplacement density selected, and on the properties of the hydrogeologic regime surrounding the repository.

Spent nuclear fuel emplaced in the VA design for the Yucca Mountain Repository will initially generate about 100 kW/acre of thermal energy (DOE 1998, p. 3-23). This thermal loading will perturb the hydrology of the repository for a considerable period of time and will affect fluid flow and transport in the unsaturated zone. Thermal hydrology addresses the temporal and spatial impact of the spent fuel heat output on repository hydrology both in the natural geologic system and the engineered barrier system. Heat from the spent fuel can dry out the region surrounding the drifts, causing water vapor to be transported to cooler regions where it condenses. The water can then flow under gravity and capillary forces. In addition, the heat may alter apertures in the fractured rock creating different paths for fluid flow. As the waste packages cool down due to radioactive decay, the processes will to some extent reverse.

At an added level of complexity, coupled processes involving thermal-hydrologic-mechanical (THM) and thermal-hydrologic-chemical (THC) modeling need to be addressed for a more realistic model of the repository system. THM processes can result in permanent displacement of the rocks from their original positions which in turn can result in permanent flow path changes. Similarly, THC processes can cause mineral dissolution and precipitation which can permanently alter seepage flow. THC processes can also alter the composition of the seepage water. These coupled processes were not examined in detail in the TSPA-VA and were not included in the base case modeling. The TSPA-VA assumed that the influence of thermal-hydrologic processes will be short-lived and there will be no permanent alteration in the hydrologic properties of the system.

The thermal hydrology models provides input to various downstream models including:

- Drift wall temperature for the near-field geochemical environment model
- Waste package temperature for waste package degradation model

- Waste package relative humidity for waste package degradation model
- Waste package temperature for waste form degradation model
- Invert liquid saturation for the engineered barrier system transport model
- Air mass fraction for the near-field geochemical environment model
- Gas phase mass flux for the near-field geochemical environment model

1.0 TSPA-VA MODELING APPROACH

TSPA-VA thermal hydrology modeling involves consideration of both drift-scale and mountain-scale thermal hydrology. Mountain-scale thermal hydrology, including repository edge effects and center effects is evaluated using a generalized equivalent continuum flow model. Drift-scale thermal hydrology is modeled using a dual permeability flow model which considers both matrix and fracture flow. Drift-scale modeling also considers waste package variability.

Mountain-scale modeling addresses the movement of gas and liquids through fractures on a broad scale (i.e., hundreds to thousands of meters). The mountain-scale model uses the stratigraphy and hydrologic properties established for the unsaturated zone flow model including the base infiltration flow field. A three-dimensional mountain-scale model which considers only heat transfer by conduction was used to develop certain parameters for the drift-scale thermal hydrology modeling. A two-dimensional mountain-scale model involving an east-west cross section through the center of the repository was used to obtain the air mass fraction and gas flux needed in the near-field geochemical environment models.

Drift-scale modeling involves dividing the repository into six regions with differing hydrologic properties. Waste package surface temperature and relative humidity are calculated for seven different waste packages within each of the six regions. This information is used to model variability in waste package degradation on a package by package basis. The drift-scale model also calculates the average waste form temperature and liquid saturation in the invert for each of the six regions. These parameters are then used in modeling waste form degradation. In addition, the model calculates the average drift wall temperature, drift wall relative humidity, and invert liquid saturation at the center of the repository. The information is then fed to the near-field geochemical models (Volume 3, p. 4-7). All of these results are generated for each of three unsaturated zone flow fields which embrace differing infiltration rates and fracture openings.

2.0 MODELING RESULTS

After about 100 years, only small variations in waste package temperature exist among the various regions (i.e., about 30°C maximum), and after 10,000 years the temperature in all regions is about the same. Initially waste packages near the edge of the repository cool more rapidly than those near the center (Volume 3, Figure 3-21). Variations in waste package temperature and relative humidity within a repository region are also predicted. Relative humidity differences become insignificant after 1,000 years while temperature differences persist until about 40,000 years (Volume 3, Figures 3-22 and 3-23). Comparison of the base case determination of the waste package temperature with the temperature based on an alternative property set using a much lower diffusivity for the rock matrix and with the temperature based on an alternative flow model showed little difference after 100 years.

An alternative repository design using backfill was also evaluated with the thermal hydrology model. The impact of either quartz sand or crushed tuff emplaced 100 years after initial waste disposal was examined (Chapter 3, p. 3-130). With either fill material the average waste package temperature increased 70 to 100°C at the time of backfill and reached a maximum of 240°C with crushed tuff in the hottest region (Region CC) of the repository. With the sand backfill, the relative humidity at the waste package surface remains below 85% for 10,000 to 20,000 years as compared to the base case (i.e., no backfill), where this low humidity exists for less than 1,000 years (see Figures 3-133 through 3-138). An unquantified trade off exists between extended waste package life due to lower relative humidity and increased fuel rod cladding failures driven by the higher temperatures.

3.0 POTENTIAL TO REDUCE DATA UNCERTAINTIES

The planned drift-scale thermal test should provide additional data for the thermal hydrology models. The TSPA Peer Review Panel felt this test is particularly important, noting that it would "constitute a major step forward in the process of understanding the complex behavior of the proposed repository. Underground testing in fractured tuff on this scale has never before been performed. It is anticipated that the results will provide data that will lead to a reduction of uncertainties" (PRP 1999). However, results from only the early heating period will be available at the time the TSPA-LA is prepared (Volume 3, p. 6-21). No cooling results will be available. According to DOE, information from the heated drift-scale test will (Volume 3, p. 6-21):

- Allow important verification of the conceptual flow models currently being used (or show the degree to which the current models are not adequate)
- Provide information on the effective hydrologic properties during various stages of heating and cooling
- Provide information on the spatial and temporal extent of mechanical and chemical changes to the fracture-flow system surrounding the heated drift.

3.1 Modeling and Abstraction Uncertainties

A major shortcoming of the current modeling approach is that it does not take into account the coupled THM and THC processes. While preliminary work in the TSPA-VA suggests that the THM coupling is not of significance, the same cannot be said for THC coupling. Formation of a precipitation cap over the drift could markedly alter seepage into the drift. As shown in Figure 4-34 (Volume 3), the fraction of waste packages contacted by seepage water is the most important factor affecting uncertainty in the peak dose for all time periods. Thus, failure to model the THC processes may result in major misconceptions about repository performance.

Some preliminary modeling of the effects of a precipitation cap are described in Chapter 3 of the Technical Basis Document (p. 3-159). The effects of a cap caused by reactive transport of silica were deemed not to cause large enough differences in temperature and relative humidity to significantly alter waste package corrosion. However, DOE recognized the need for additional studies to support the license application.

3.1.1 Impact on Performance Assessment

The thermal hydrology modeling provides critical input to downstream models. The waste package is the major barrier to release of radionuclides. The corrosion of the waste package is driven by the temperature and humidity as predicted by the thermal hydrology model. Credible predictions of these parameters are essential to a credible modeling of waste package behavior. Waste package performance is also affected in a major way by the fraction of waste packages that are intercepted by seeps. The coupled modeling, which would elucidate how the seepage factor might be altered by mechanical and chemical interactions, was not considered except very superficially in the TSPA. DOE recognizes that coupled processes must be addressed (Volume 3, p. 3-20).

The refluxing of water above the drifts can cause minerals to dissolve where condensation occurs. This water can then travel downward by gravity until it reaches rocks with temperatures above the boiling point and is again evaporated leaving behind a precipitate which can build into a cap above the drift over time. This cap can alter and control the seepage flow onto the waste packages. The TSPA Peer Review Panel has noted that understanding how the precipitate cap controls seepage is of critical importance in establishing how the repository environment will change with time and affect the distribution and quantity of water flowing through the repository (PRP 1999). This, in turn, has major implications as to waste package performance. According to the panel "the coupled effects and their absence from the TSPA-VA are a significant cause of concern" (PRP 1999, p. 53).

The TSPA-VA assumes that seepage occurs at fixed locations for a fixed climate. Coupled THC and THM modeling will likely show that this assumption is not realistic. It was not clear to the TSPA Peer Review Panel whether coupled effects on flow path alteration are conservative or non-conservative (PRP 1999, p. 56). The panel questioned whether the evaluation of coupled THC and THM processes was too complex to permit meaningful calculations. If so, the panel suggested that some type of bounding analysis would be required.

In addition, the TSPA Peer Review Panel did not accept DOE's view that effects of the thermal pulse are short-lived. The panel noted that, while boiling may cease after 5,000 years, cool down of the rock is a slow process. Furthermore, dissolution of any precipitate cap may take ten of thousands of years.

Clearly, modeling of the thermal hydrology at Yucca Mountain requires considerable refinement over that presented in the TSPA-VA. The thermal hydrology models must be supported by adequate experimentation to provide a credible basis for the modeling assumptions.

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APPENDIX E

MODELING OF THE NEAR FIELD GEOCHEMICAL ENVIRONMENT IN THE TSPA-VA

MODELING OF THE NEAR FIELD GEOCHEMICAL ENVIRONMENT IN THE TSPA-VA

1.0 INTRODUCTION

The near field geochemical environment (NFGE) is composed of the gases, water, solids, and colloids within and near the drifts that contain the waste packages. The characteristics of this environment will affect the rate and means by which waste packages and waste forms are degraded, and the rates and means by which radionuclides are mobilized and transported through the Engineered Barrier System. The characteristics of all of the performance parameters involved in these processes are expected to change with time because temperatures in the repository will change with time.

The Viability Assessment (VA) repository is designed to produce a temperature pulse in the rocks surrounding the repository soon after disposal, thereby keeping water from entering the drifts for as long as possible. After temperatures become low enough as a result of radioactive decay and reduced heat emissions from the waste packages, the water, along with gases, can seep into the repository through the drift walls and initiate aqueous-based degradation processes. The characteristics of these processes will depend on the characteristics of the repository contents as well as the characteristics of the incoming materials; the repository introduces large masses of foreign materials, such as concrete and steel, to the natural environment.

The NFGE will evolve with time, because temperatures will initially rise and then fall as a result of loading the repository with wastes and subsequent radioactive decay of the radionuclides in the wastes. Under design parameters selected for the VA repository, the temperature of the drift walls would rise to about 150 degrees C during the first one hundred years after disposal, fall to about 50 degrees C after 10,000 years, and return to temperature levels characteristic of the unperturbed natural environment, about 28 degrees C, only after about 100,000 years.

The temperature pulse will cause chemical reactions to occur, at rates dependent on local temperatures, with consequences to compositions of the gases, liquid, and solids dependent in part on their initial compositions. "Local conditions" may also change as a result of the thermal pulse, which can produce consequences such as change of the hydrologic regime because of mechanical effects on the rocks, and collapse of the drift liner. In short, the thermal, hydrologic, chemical, and mechanical phenomena and effects associated with the thermal pulse are all coupled, and the consequences of the pulse and the couplings will depend on the size of the thermal pulse, the initial conditions, and the local conditions as they evolve with time.

The challenge for TSPA-VA characterization of the NFGE is to model the evolution of the near field geochemical conditions, as a result of the thermal pulse, material conditions, and coupled processes, for purposes of evaluating the consequences in terms of radionuclide mobilization and release from the EBS. This appendix describes the modeling approach and information base used in the TSPA-VA to meet these objectives. Details of the TSPA-VA effort, which was the first of its kind, are provided in Chapter 4 of the TSPA-VA Technical Basis Document (DOE 1998a).

2.0 TSPA-VA MODELING OF THE NEAR FIELD GEOCHEMICAL ENVIRONMENT

The TSPA-VA modeled the coupled phenomena and processes that affect waste package degradation in terms of five independent but interactive models:

- Compositions of the incoming gas, water, and colloid phases as they enter the drift
- In-drift gas phase composition
- Evolution of in-drift water composition and water/solid interaction
- Characteristics of the in-drift colloids
- Characteristics of the in-drift microbial communities

This representation of the near field geochemical environment is shown graphically in Figure E-1, which is reproduced from Volume 3 of the VA report (DOE 1998b). The diagram shows the interactions between the five models that were defined to apply and were used to represent the coupled thermal, hydrologic, chemical, and mechanical effects. In the TSPA-VA, submodels were also used to model the interaction of water and solids to produce steel corrosion products, degradation of concrete, degradation of the waste form, and formation of mineral precipitates in the rocks around the drifts as a result of boiling caused by the high heat load.

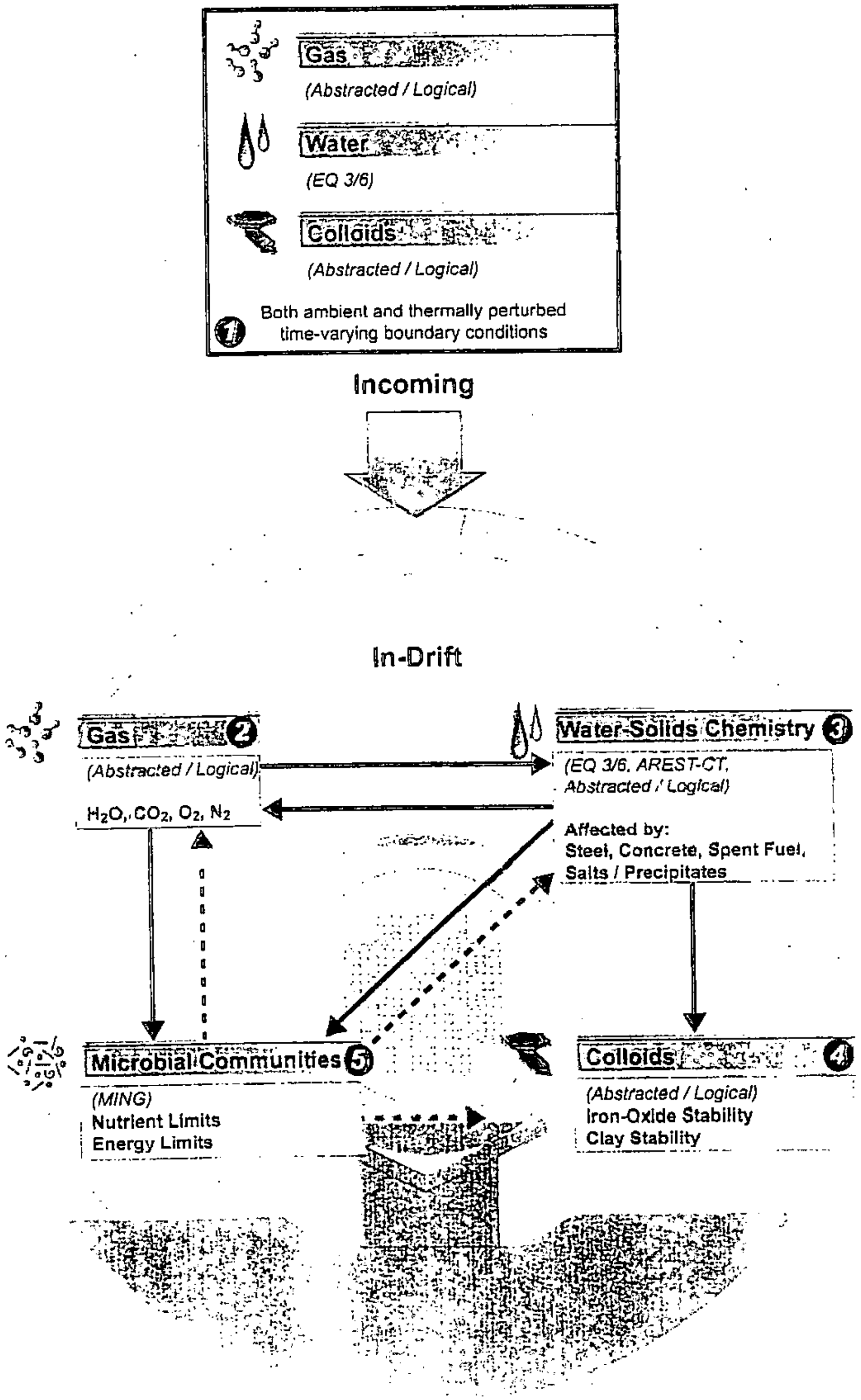

Figure E-1. Relationships Between the Five Near Field Geochemical Environment Models (Source: DOE 1998a, Volume 3)

The NFGE models have connections with other repository system component models. The NFGE models receive inputs from the unsaturated zone flow models and the thermal-hydrology models, and they provide outputs to the waste package degradation model, the waste form degradation models, the unsaturated zone radionuclide transport model, and the nuclear criticality model. The principal interactions between these models are shown schematically in terms of performance parameters in Figure E-2. Key features of these interactions are described below.

- The flow and composition of water from the unsaturated zone above the repository are described in terms of the seepage flux through the drifts for the in-drift water/solids model and for the colloids model. Average percolation flux (of which seepage flux is a part) was used for the in-drift gas model because of the higher mobility of gas compared to the water and solids and the larger scale of gas phase interactions.

- The thermal hydrology models provide time-dependent boundary conditions for the near field geochemical environment models. Factors affected include fluxes and compositions of ground water and gases in the drift and changes in mineralization and flow path conditions external to the drift.

- Corrosion of waste package barrier materials (in the VA design, steel and high-nickel Alloy 22) is linked to gas and liquid phase compositions described by the near field geochemical models. Corrosion phenomena are dependent on local conditions (e.g., the conditions at a specific location on a waste package surface which may, for example, be affected by the presence of concrete from collapsed drift liner) rather than the more global in-drift geochemical conditions.

- Waste form degradation, and subsequent radionuclide mobilization and transport through the Engineered Barrier System (EBS), are dependent on the composition and temperature of the gas and aqueous phases as these phases contact the exposed waste form. The near field geochemical models provide values for these parameters.

- Radionuclide transport in the unsaturated zone beneath the repository depends on the composition of the ground water as it leaves the EBS and on phenomena that occur along the pathways through the unsaturated zone. These phenomena can include radionuclide retardation as a result of sorption processes and alteration of the pathways as a result of the heat load on the geologic formations.

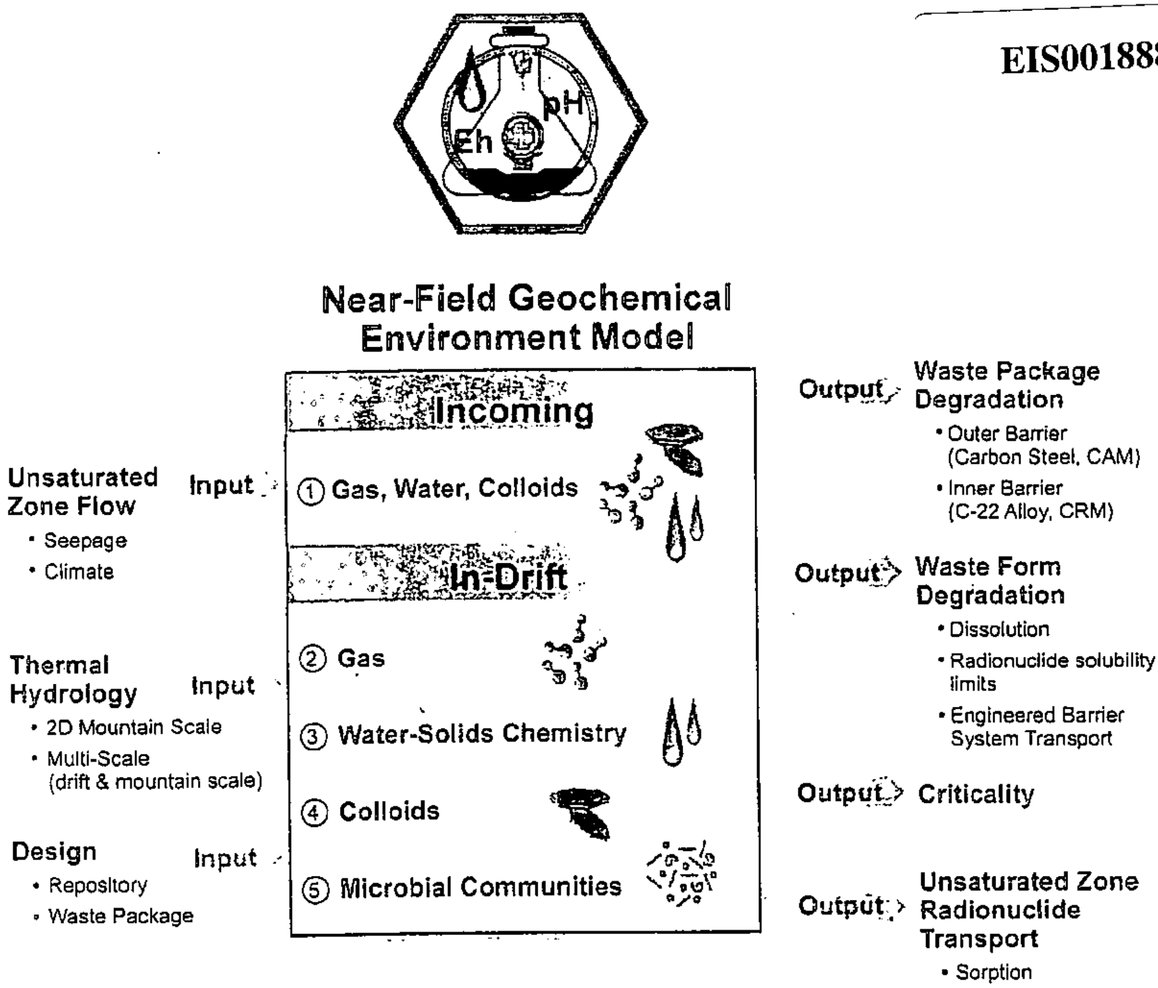

Figure E-2. Interconnections Between Near Field Geochemical Environment Component and Other TSPA-VA Modeling System Components (CAM - corrosion allowance material; CRM - corrosion resistant material) (Source: DOE 1998a, Volume 3)

Radionuclide compositions and concentrations in ground water as it emerges from unsaturated zone transit at the unsaturated/saturated zone interface become the initial condition for modeling of flow and transport in the saturated zone. These phenomena are addressed in the saturated zone flow and transport models for the TSPA-VA.

The overall results of modeling of the near field geochemical environment are predictions of the time and spatial variations of values of parameters important to degradation and radionuclide transport processes such as waste package corrosion, waste form degradation, and radionuclide mobilization. The parameters addressed include pH, Eh, ionic strength of water in the drifts, carbonate concentrations in the water in the drifts, etc. The time variation of parameter values was evaluated using a sequence of steady-state near field geochemical environment model conditions.

The TSPA-VA modeled the time variation of the NFGE as a sequence of steady-state conditions. As a consequence of this approach, the changes in conditions were described as a series of stepwise changes. The type of results obtained is illustrated in Figure E-3, which shows the effect of alternative reaction pathways, iron oxides, and concrete on the pH of the incoming water. The pH profile for the incoming water shows a high pH of about 10 during the 2,000-year boiling period, followed by a drop to a pH of about 8 at 10,000 years. The profile for reaction with iron oxides is similar, indicating that this pathway for evolution of the NFGE has little effect on pH. In contrast, the pathway for reaction with concrete, which was not included in the base case but was addressed in sensitivity studies, shows an increase in pH to 11 after the boiling period, followed by a drop to a pH of 7.5 after 10,000 years. In the TSPA-VA modeling of the NFGE, the sequence of stepwise changes that represent the transients in NFGE conditions are all complete at 10,000 years.

3.0 TECHNICAL ISSUES IN MODELING OF THE NEAR FIELD GEOCHEMICAL ENVIRONMENT

The TSPA-VA was the first attempt by the Yucca Mountain Project to construct the NFGE component models for the TSPA analyses. In the three prior TSPA reports the NFGE parameters were incorporated as composition variables within subsystem models or within the uncertainty range for other parameters. The technical issues associated with this modeling effort therefore have a limited historical basis. They also have, as discussed in the VA documentation, a limited data basis for setting parameter values and uncertainty ranges.

Two types of technical issues are associated with modeling of the near field geochemical environment in the TSPA-VA: those associated with the information base for the modeling, and those associated with the modeling itself. The characteristics of the issues can be illustrated by noting that a high degree of temporal and spatial variability in values of parameters important to near field geochemical conditions is to be expected, but the data base for selecting values for the TSPA-VA was sparse, as noted above. Similarly, the coupling of thermal, hydrologic, chemical, and mechanical phenomena is fundamental to the temporal and spatial variation of near field geochemical environment conditions, but the phenomena were uncoupled in the TSPA-VA models.

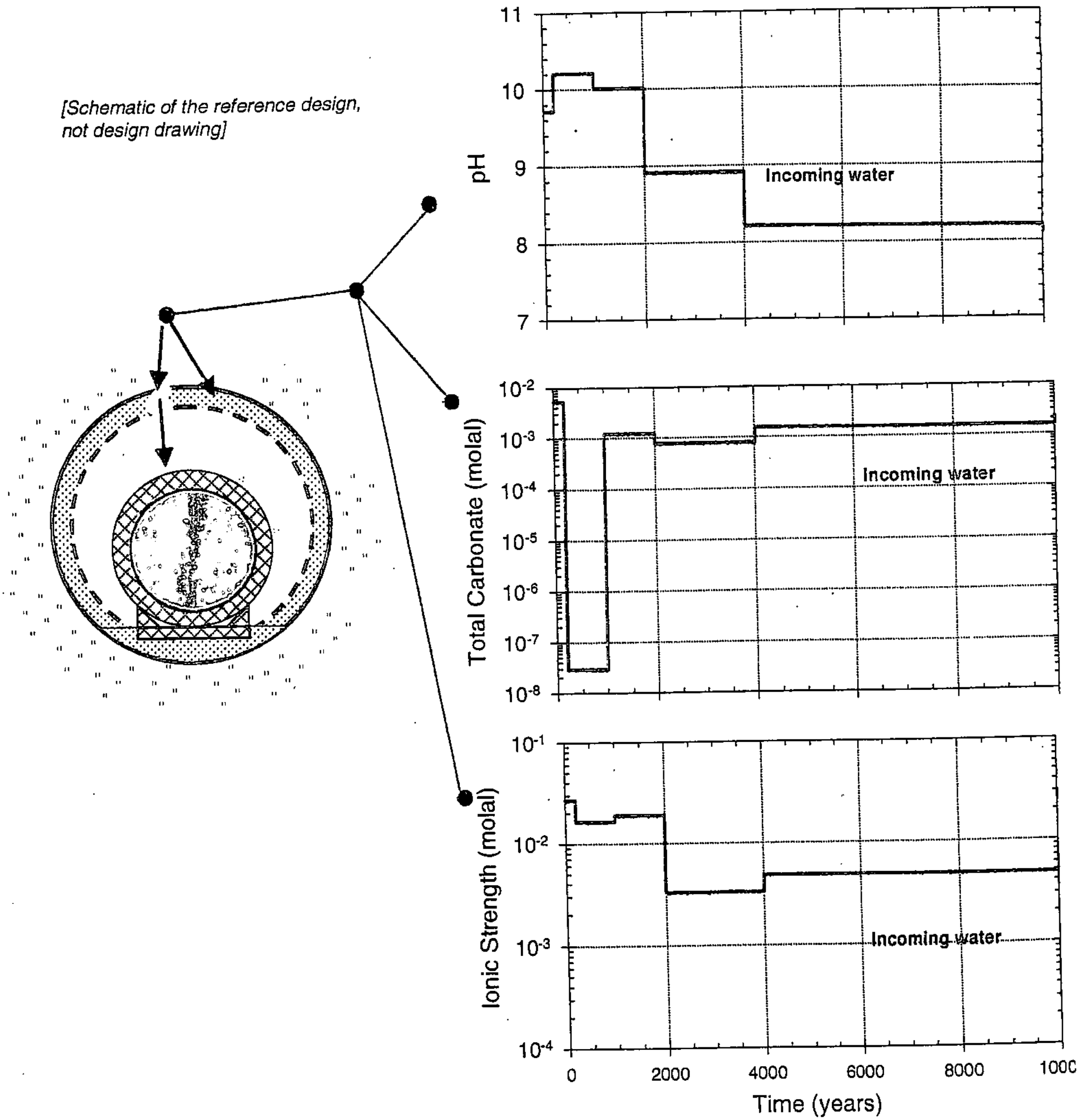

Figure E-3 Illustration of Results of Modeling of the Near Field Geochemical Environment (Source: DOE 1998a, Volume 3)

3.1 NFGE Modeling Issues

With respect to modeling of the coupling of thermal, hydrologic, chemical, and mechanical phenomena, Chapter 4 of the Technical Basis Document (DOE 1998a) notes that, in general, the TSPA-VA model architecture is based on the ability to decouple interactive elements of system behavior and to adequately represent the interactions through linked component models. Chapter 4 also noted that this assumption is least tenable when applied to the near field geochemical environment, for which coupling may be highly important and nonlinear; work to "delineate the first-order couplings that should be addressed and to define the magnitude of the effects of representing inherently coupled processes by uncoupled, or loosely, coupled models..." was stated to be ongoing. It was also noted that all physical and chemical processes likely to occur in the repository can be considered to be thermally coupled in some way, but not all such couplings are significant to performance.

The near field geochemical environment element of the TSPA-VA is in large measure the result of a multi-disciplinary workshop held in March 1997 DOE 1998a). The workshop led directly to the five-element modeling approach to decoupling the coupled processes summarized above. It provided the basis for conceptual models of incoming gas, water, and colloids, and for models of the evolution of in-drift conditions.

As previously noted, the implementation of the modeling approach involved use of average, constant parameter values for defined time periods, with step changes between the periods. Given this concept, and given the decoupling of the coupled phenomena, modeling for each of the five areas could proceed based on known scientific principles and on the basis of available data concerning ambient conditions, processes driven by thermal perturbations, and processes driven by materials introduced to the natural environment. Detailed information on these processes, the available data base, and the conceptual models developed for the NFGE in the TSPA-VA are described in Chapter 4 of the Technical Basis Document for the TSPA-VA (DOE 1998a).

3.2 NFGE Data Base and Parameter Value Issues

Data available as of the time of preparation of the TSPA-VA from site characterization, laboratory experiments, and engineered designs provided the basis for valuation of parameters used in the NFGE models. A data basis exists for relevant site features such as gas and water compositions, and existing natural colloids; these data provide a basis for characterization of incoming gas, solids and colloids in the NFGE models. Similarly, there are data on factors such as metal corrosion characteristics, pore water compositions in concrete, degradation of waste forms, and existing microbial communities at the site, and the VA-repository designs provide information on quantities of materials such as concrete and steel introduced to the repository system. These data are used in the phenomenological models that describe the evolution of the NFGE. Available data and their sources, and the detailed phenomenological models, are cited and discussed (in over 100 pages) in the Technical Basis Document (DOE 1998a).

Uncertainties or deficiencies in the existing data base essentially constitute a baseline for uncertainties in parameter values associated with evolution of the NFGE. As illustrated by Figure E-3, the variation of parameter values with time that emerges from the modeling approach in which coupled phenomena are uncoupled and steady-state is assumed for sequential time periods is extremely complex. The TSPA-VA dealt with these variations in a process in which values such as those shown in Figure E-3 were treated as deterministic values, alternative conceptual pathways for evolution of the NFGE were considered, and standard deviations were assigned to the calculated expected values for the pathways. This approach produced results such as those shown in Figure E-4. In Figure E-4, the probability distribution functions are shown at the end of the period of their applicability to the system, e.g., the distribution shown for 100,000 years applies to the period from 10,000 to 100,000 years.

4.0 DISCUSSION OF NFGE MODELING RESULTS

As stated in Chapter 4 of the Technical Basis Document for the TSPA-VA:

> *"The NFGE component does not directly change a performance parameter such as a release rate from the EBS. Rather, the mechanism for the NFGE results to affect the system consequences is through the other TSPA-VA component models. These other components such as the WP [waste package] evolution and the waste form evolution can affect changes to the performance more directly, and the NFGE contributes to that only by how those models respond to the changes in environment parameters."* (DOE 1998a, page 4-112)

The NFGE component of the TSPA-VA modeling scheme can therefore be thought of as providing "connective tissue" for the parameters that directly affect forecasts of system

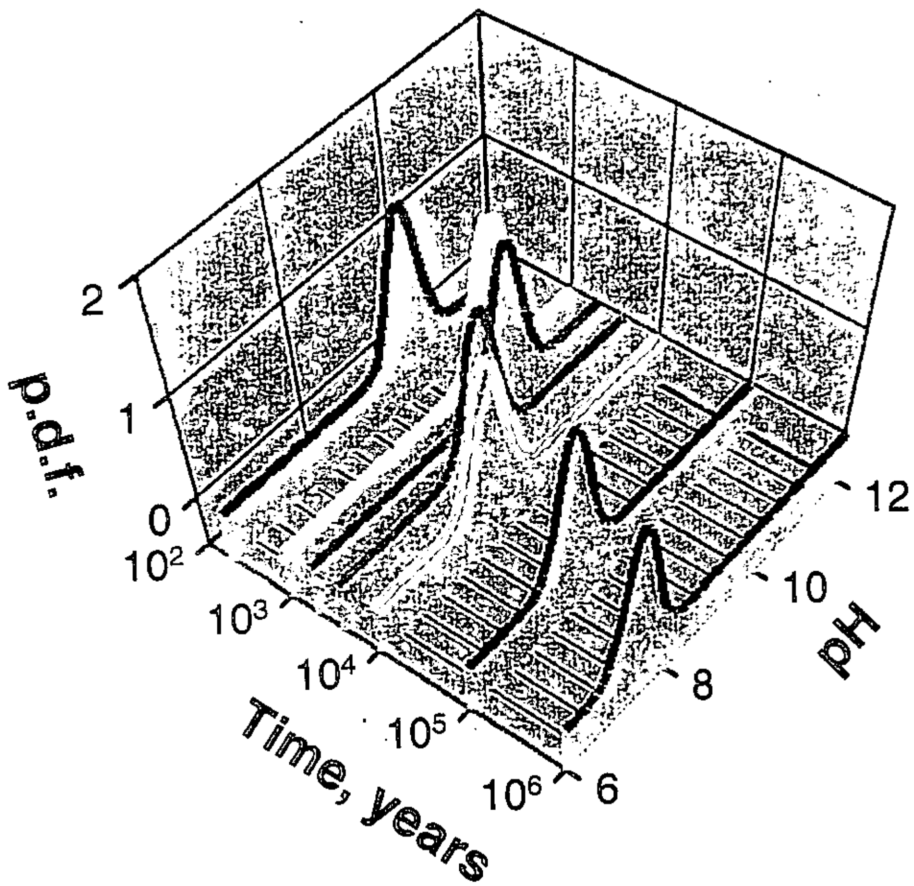

Figure E-4. Illustration of Input to the TSPA-VA From Modeling of Near Field Geochemical Environment (p.d.f. - probability density functions) (Source: DOE 1998a, Vol. 3)

performance. Important questions concerning the NFGE component for the TSPA-VA are, therefore, whether or not the connections described are sound, and whether or not the connections are important to the TSPA-VA results.

Because of the uncoupling in the TSPA-VA's NFGE models of thermal, hydrologic, chemical, and mechanical phenomena that are known to be coupled, it is uncertain whether the connections have been made correctly, i.e., whether the uncoupling has eliminated consideration of couplings that are actually significant to repository performance. Clear resolution of this issue is unlikely, because it is not possible to develop a data base, except perhaps during the confirmation phase after disposal, to show definitively how the coupling can and should be modeled.

Within the framework of TSPA-VA models and modeling assumptions, resolution of the question of whether NFGE coupling is weakly or significantly important to performance, especially during the first 10,000 years after disposal, may be obviated by the dominant effect of assumptions concerning juvenile failure and climate change on the TSPA-VA results. As indicated by the preceding quotation from the Technical Basis Document, the effect of the near field models and parameters would be expected to be manifested in the TSPA-VA's projections of the rate of package failure, the area of exposed waste form as a function of time, and the radionuclide release rate from the waste form.

Sensitivity studies on the effect of the number of juvenile failures at 1,000 years showed that the dose rate peak that occurs at about 5,000 years as a result of such failures is directly proportional to the number of failures assumed. The effect of such failures is submerged by other, subsequent failures at 10,000 years and beyond. This results suggests that the effects of juvenile failure assumptions, under TSPA-VA modeling methods, would indeed be dominant up to 10,000 years, but NFGE conditions at 10,000 years would be important to performance after 10,000 years.

The TSPA-VA modeling approach for the NFGE which would lead to waste package and waste form degradation rates is shown in Figure E-5. Parallel paths of reaction of incoming water with steel corrosion products and with concrete are shown to establish the chemistry parameters which become the basis for performance parameters such as waste package corrosion rates. In the TSPA-VA base case, the concrete path was not used because it was assumed that the concrete liner would collapse during the 500 to 10,000 year period, and water would therefore drip directly onto the waste packages. The concrete path was investigated in sensitivity studies, which concluded that the high pH water established by reaction of incoming water would greatly accelerate waste package failure rates. This effect was not, however, part of the base case, and it may be that the assumed effect of high pH water on the corrosion rate of the corrosion-resistant material was excessively conservative.

5.0 REFERENCES

DOE 1998a — CRWMS M&O, Total System Performance Assessment-Viability Assessment (TSPA-VA) Analyses Technical Basis Document, Chapter 4, Near Field Geochemical Environment, B00000000-01717-4301-00004 REV 1, November 13, 1998.

DOE 1998b — U.S. Department of Energy. Viability Assessment of a Repository at Yucca Mountain, Volume 3, Total System Performance Assessment, DOE/RW-0508, December 1998.

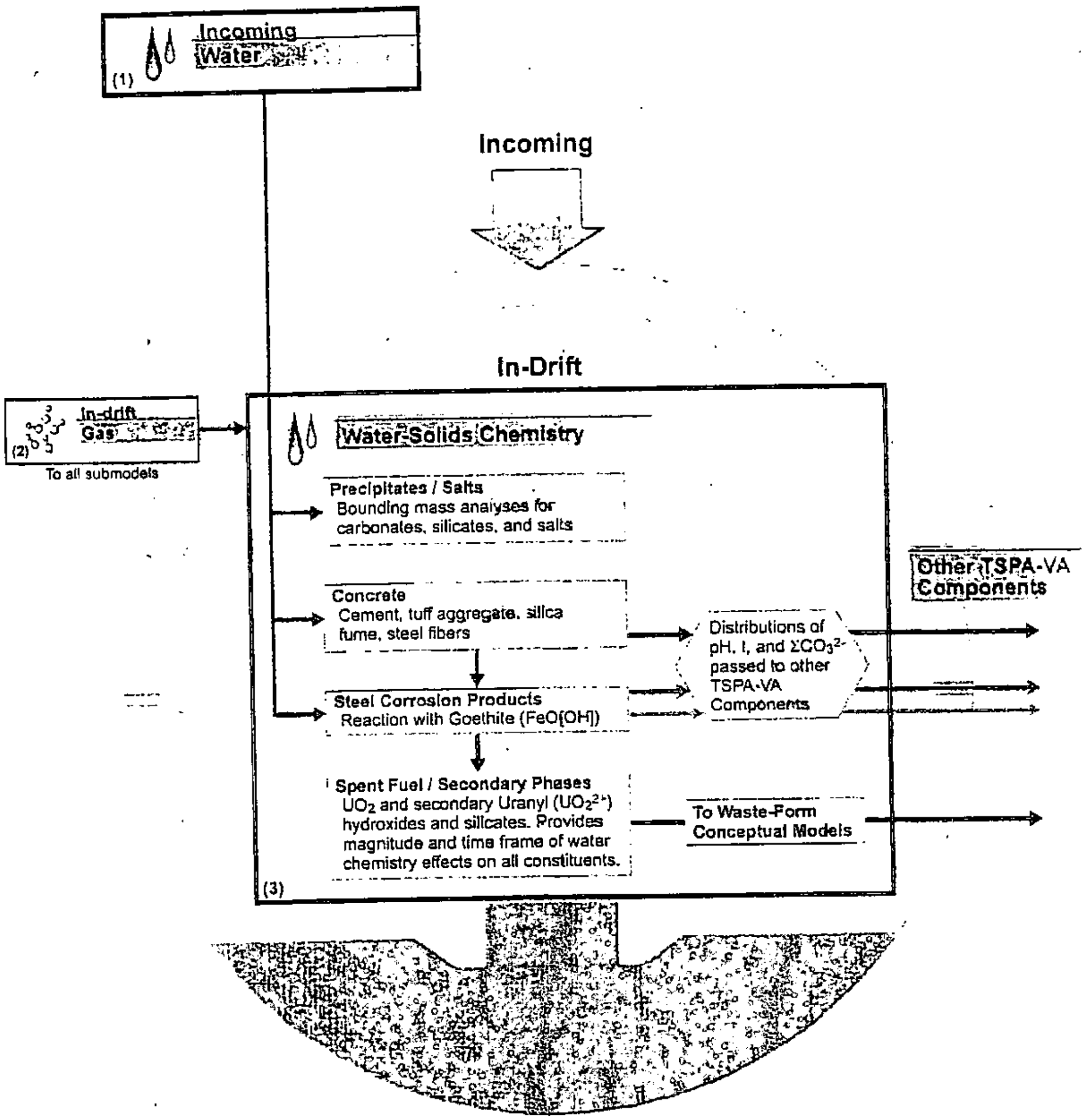

Figure E-5. NFGE Model Connections to Produce Parameter Values (Source: DOE 1998b)

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APPENDIX F

MODELING OF THE BIOSPHERE IN THE TSPA-VA

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MODELING OF THE BIOSPHERE IN THE TSPA-VA

1.0 INTRODUCTION

To determine whether the proposed Yucca Mountain repository will be able to comply with a regulatory standard that specifies a dose (or risk limit), a comprehensive model (i.e., TSPA model) must be employed in which the biosphere represents the terminal component.

According to current understanding, the principal route by which radionuclides in the future repository could expose humans in the accessible environment is by way of contaminated ground water. Thus, steps in the TSPA model include the degradation of waste packages and the migration of radionuclides through the engineered and geologic barriers of the repository. Materials released from the repository will then be transported downward through an unsaturated zone toward the underlying aquifer. Current estimates suggest transit times to the water table of several thousands of years. Once radionuclides reach the aquifer, they would be transported away from the vicinity of the repository in the direction of ground-water flow, which is generally southwest from the proposed site. Thus, within the breached aquifer, there would be a plume of contaminated ground water that would steadily move away from the vicinity of the repository to areas where water may be withdrawn from wells for human consumption or for agricultural uses including crop irrigation and drinking water for farm animals raised for human consumption. It is this terminal phase that defines the biosphere model.

To proceed from contaminated well water concentrations at various locations and times to calculations of doses and risks to a population group requires the development of a biosphere model that specifies discrete pathways and quantifies the intakes of individual radionuclides. Depending upon the potential uses of contaminated well water, prominent pathways for human exposure will include internal exposure from the ingestion of contaminated drinking water, vegetables, fruits, dairy products, and meats. For persons engaged in agricultural activities, internal exposure may also result from the inhalation of airborne contaminants resuspended from soil that has been irrigated with contaminated water.

The selection of one or more exposure scenarios appropriate for compliance assessment, therefore, requires not only a complex array of parameter values that define potential radionuclide concentrations in various media to which individuals may be exposed but must also provide quantitative descriptions of where individuals live, what they eat and drink, and their sources of food and water. Not surprisingly, many key parameters needed to model human exposures at Yucca Mountain are highly site-specific. Parameters considered highly site-specific largely reflect the desert conditions of the sparsely populated Amargosa Valley. For example, the combined impacts of low rainfall, desert temperatures, and soil quality limit land use for farming. However, these very conditions mandate extensive irrigation of farm crops and use of local ground water for raising farm animals. Under these conditions, contaminated well water has the potential for unusually high activity concentrations in all locally grown food products.

Our review of the TSPA-VA biosphere model is presented in two sections. Section I focuses on the identity of the individual (or group of individuals) for whom the standard will be written and for whom regulatory compliance must be demonstrated. Section II addresses specific model parameters that were employed in the TSPA-VA biosphere model.

2.0 SECTION I: ASSESSMENT OF CRITICAL TARGETS

The release of radionuclides from the repository to the accessible environment is likely to expose a sizeable number of individuals. Within the exposed population, radiation doses and associated health risks can be assumed to vary from low or negligible levels to some maximal level. The choice of who is to be protected within this population will, therefore, profoundly affect the calculated dose and determine whether or not a prescribed standard can be met. For compliance assessment, the selection of the target receptor is generally restricted to those individuals within the exposed population who are likely to receive the highest exposure.

2.1 EPA Guidance

In 1992, the U.S. Congress passed the Energy Policy Act (EPA), which directs the Environmental Protection Agency to develop standards for the future disposal of radioactive waste at Yucca Mountain, Nevada. For risk assessment, the U.S. EPA traditionally requires that the standard:

> *...should be based on an estimate of the reasonable maximum exposure (RME) expected to occur under both current and future land use conditions. The reasonable maximum exposure is defined here as the highest exposure that is reasonably expected to occur at a site . . . The intent of the RME is to estimate a*

conservative exposure case (i.e., well above the average) that is still within the range of possible exposures. [Emphasis added]

The U.S. EPA also states that:

Information about individual exposure and risk is important to communicating the results of a risk assessment. Individual risk descriptors are intended to address questions dealing with risks borne by individuals within a population. These questions can take the form of:

- *Who are the people at the highest risk?*
- *What risk levels are they subjected to?*
- *What are they doing, where do they live, etc., that might be putting them at high risk?*
- *What is the average risk for individuals in the population?*

The high end of the risk distribution is, conceptually, above the 90th percentile of the actual (either measured or estimated) distribution. The conceptual range is not meant to precisely define the limits of this descriptor, but should be used by the assessor as a target range for characterizing "high end risk." [Emphasis added]

2.2 Recommendations by the National Academy of Sciences

The 1992 Energy Policy Act also instructed the National Academy of Sciences (NAS) to conduct a scientific analysis of the standard to be applied at the Yucca Mountain disposal site. In their 1995 report, the NAS Committee recommends a repository standard be set to a limit-specified by the EPA-based on the risk of adverse health effects for individuals at the highest risk (NAS 1995). Protecting individuals at the highest level-by keeping them below the exposure limit-helps to protect everyone in a larger exposed population.

On the premise that potential releases of radionuclides from an undisturbed repository into the accessible environment will not occur for thousands of years following repository closure, any standard that intends to protect members of the public will require specific assumptions regarding the future: population distribution near Yucca Mountain; land use for farming and residential communities; personal lifestyles and activities; and use of local ground water resources.

Recognizing the difficulties of making assumptions about the future, the NAS Committee offered two very different approaches to describe the individual(s) at the highest risk and to demonstrate compliance. The simpler approach identifies a subsistence farmer as the principal representative of the critical group (Appendix D of NAS 1995). The second and more complicated approach employs statistical methods and probabilities to characterize a critical group as defined by the ICRP (ICRP 1985) and described in Appendix B of NAS 1995.

A brief description of these two methods is provided below for reference and comparison to the three "receptors" identified by TSPA-VA.

2.2.1 Option #1: Characteristics of Subsistence Farmer

Historically, the subsistence farmer model has been used to assess risks and to set standards. In theory, the farmer represents an individual at the upper limit of exposure, and his or her activities put this person at or near maximum risk (NAS 1995, Appendix D, p. 155):

> *The critical assumption in this model, then, is that a subsistence farmer extracts water from the location of maximum concentration of radionuclides in the aquifer, provided that no natural geologic feature precludes drilling for water at that location.*
>
> *The subsistence farmer is assumed to use the extracted contaminated water to grow his food and for all his potable water. Conservatively, the farmer is to receive no food from other sources. [Emphasis added]*

2.2.2 Option #2: The Probabilistic Critical Group Approach

To avoid a standard based on persons who represent an extreme condition, the NAS Committee on Technical Bases for Yucca Mountain Standards also endorsed the use of the critical group in developing a standard. The critical group is defined by the ICRP (ICRP 1977, ICRP 1985) as a relatively homogeneous group of people whose location and lifestyle are such that they represent those individuals expected to receive the highest doses as a result of radioactive releases. As part of the critical group definition, the ICRP specifies the following additional criteria:

- Size - The critical group should be small in number and typically include a few to a few tens of persons.

- Homogeneity among members of the critical group - There should be a relatively small difference between those receiving the highest and the lowest doses. It is recommended that the range between the low and high doses not differ by more than a factor of ten or a factor of about three on either side of the critical group average.

- Magnitude of dose/risk - It is suggested that the regulatory limit defined by a standard exceed the calculated average critical group dose by at least a factor of ten.

- Modeling assumptions - In modeling exposure for the critical group, the ICRP recommends that dose estimates be based on cautious but reasonable assumptions.

In principle, the critical group concept adequately meets the objectives of protecting the vast majority of the public since the individuals in the critical group can be expected to receive the highest doses based on cautious, but reasonable, assumptions. The group should be small enough to be relatively homogeneous with regard to factors that affect the magnitude of exposure and risk.

The ICRP, however, does not prescribe the lifestyle, habits, or conditions of exposure that may define a critical group in the far future. Rather, its generic recommendations are limited to the need to use current knowledge and the use of cautious but reasonable assumptions for characterizing future exposure scenarios.

In summary, the critical group is expected to consist of some tens of individuals who by their location, lifestyle, and activities can be expected to receive the highest dose within the exposed population (Figure 1). Although these individuals are not expected to be identical in all aspects of life, they should be sufficiently similar so that the range of risk between the lowest and highest member does not differ by more than a factor of 10.

In the present and near future, members of the critical group are real and represent persons currently living in the vicinity of the proposed repository. Thus, if several subsistence farmers now live near Yucca Mountain, the critical group in effect would be defined by these farmers, which leads us back to Option #1. Likewise, if current information reveals that individuals at maximum risk include a cluster of residents whose drinking water comes from one common well, the critical group may consist of a mix of people with different lifestyles such as homemakers, office workers, professionals, skilled laborers, etc.

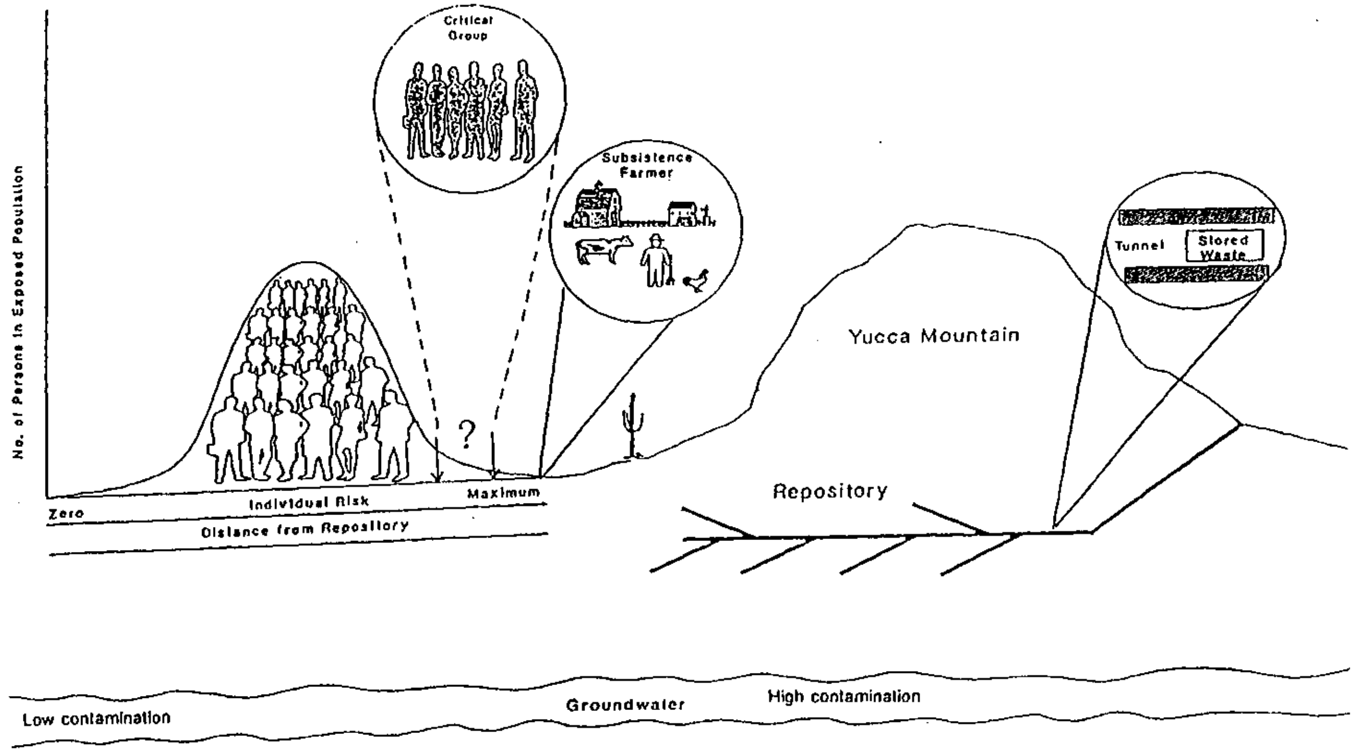

Figure 1. Models for Yucca Mountain Standards

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However, very few persons presently live within close proximity of Yucca Mountain, where future potential contamination of the underlying aquifer would be expected at near maximal levels. Present information, therefore, provides no clear method to estimate the future population, land use, and groundwater consumption at locations proximal to the proposed repository. Uncertainties about the future, involving conditions that are unknowable, can be dealt with only by making assumptions and recognizing that these conditions may not correspond to any actual future reality. For the distant future, the critical group would have to be defined by making various assumptions with regard to; (1) location of people relative to the repository, (2) their use of the land for activities like farming that may lead to exposure, (3) their individual lifestyles including dietary preferences and habits, and (4) their reliance on well water drawn from contaminated groundwater.

To minimize the uncertainty of necessary assumptions, the NAS Committee recommended that sufficient geographic and environmental information be gathered to construct maps of the Yucca Mountain area and its underlying aquifer. Specific data would be collected to define the local terrain, quality of soil, depth to ground water, well-water use, and other factors. These data would be used to determine the suitability of each location to support future populations, and its probable use for farming, residential, commercial, industrial, or other purposes. Each specific case, or "scenario," would be assigned a probability, and all of the scenarios would be combined statistically to define the probabilistic critical group.

The NAS Committee further suggested the following steps for the Monte Carlo method that implements a probabilistic assessment:

- Step 1: Identify general lifestyle characteristics of the larger population that includes the critical group
- Step 2: Quantify important characteristics, distributions of characteristics, and geographic locations of the potentially exposed population
- Step 3: Based on findings in Steps 1 and 2, model radionuclide transport for estimates of exposures to members of the critical group

The first and second steps serve to identify the larger exposed population of which the critical group is a subset receiving the highest dose and, therefore, at greatest risk. Thus, specific information on location, living patterns, lifestyles, and economic activities of potential members of the exposed population can lead to the identity and characterization of the critical group.

An important component of Step 3 is the superimposition of the critical group to area(s) that in the far future will overlay the contaminated aquifer at locations that may range from near maximum at the footprint of the repository to lower concentrations defined by the directional migration pattern of the contamination water plume.

In conclusion, current knowledge may be used as a technical basis for defining a future exposed population and its probabilistic critical group for demonstrating compliance with a repository standard.

2.3 Receptors Identified in TSPA-VA

Section 9.4 of the TSPA-VA Technical Basis Document (TBD) describes the scope and objectives of a regional demographics and food/water consumption survey:

> *. . . the strategy for the TSPA-VA is to base human demographic and living habits (kinds and quantities of foods and water consumed, time spent outdoors, hobbies [e.g., gardening], occupations [e.g., animal husbandry], etc. on actual data where possible. A regional survey was [therefore] conducted to obtain site-specific, localized data on food and water consumption habits of people living near Yucca Mountain.*

However, the survey's main purpose was not to identify and characterize individuals who might represent the critical group within the exposed population but rather "*. . . to provide site-specific data for use as, or establishment of, input parameters for the GENII-S code*" (p. 9-27).

The TBD concedes that a critical group has not been defined for Yucca Mountain as suggested by the following statements:

Page 9-7:

> *The exact nature of the critical group could not be defined because of uncertainties in the geosphere transport model and the need to extrapolate into the future. However, for purposes of the Viability Assessment, the critical group was assumed to be located in the existing community of Amargosa Valley.*

and Page 9-37:

> *The results of the regional survey on demographics and food and water consumption* <u>*support the possibility*</u> *that the "critical group" for use in the TSPA-VA biosphere modeling effort is* <u>*most likely*</u> *to reside in the community of Amargosa Valley than elsewhere in the 84 km radius surrounding the potential Yucca Mountain repository.* [Emphasis added]

In spite of the acknowledged uncertainty regarding the identity of the critical group or critical receptor, the TSPA-VA biosphere model identified three receptors: (1) subsistence farmer, (2) resident farmer, and (3) average Amargosa resident.

The TSPA-VA's subsistence farmer is described as an individual who consumes only locally-produced food and water and is engaged in subsistence farming activities; the resident farmer is one who consumes local water but only 50% of food is locally grown; the average Amargosa Valley resident was defined by means of survey data of 195 respondent households from a total pool of 452 households.

Section 9.5.2 of the TBD states that "*. . . in selecting the receptor groups, consideration was given to existing regulatory standards and the recommendations of the National Academy of Sciences Committee on Technical Bases for Yucca Mountain Standards (National Research Council 1995, pp. 95-104).*"

In spite of the significant differences that define each of the three receptor groups and the previous acknowledgment (that the critical group could not be defined), the TBD nevertheless refers to each of the three receptors as the "critical group":

- <u>Reference to the 452 households of Amargosa population as "critical group"</u>:

  > Three receptors were considered as part of the farming scenario. The first was the group of people who are members of the existing community in Amargosa Valley as defined by a regional survey conducted in the vicinity of Yucca Mountain in 1997. As this receptor is based on the existing population, it is considered to be representative of the critical population group. Throughout this chapter parameters defined for this group are referred to as being applicable to the average Amargosa Valley community resident. [Emphasis added.] (page 9-2)

The TSPA-VA base case modeling considers a reference adult living 20 km from the proposed repository. A component of this reference biosphere comprises the population near the site. This population, referred to as the "critical group (page 9-27)

- Reference to the resident farmer as the "critical group"

  No one interviewed in the survey area (Amargosa Valley community or beyond) completely met the criteria established for the subsistence farmer receptor. The resident farmer is more likely to be the average member of the critical farmer group. [Emphasis added.] (page 9-37)

- Reference to the subsistence farmer as the "critical group"

  The limiting critical group was identified by the National Academy of Sciences Committee (National Research Council 1995, Appendix D) as a subsistence farmer. Such a farmer is assumed to use groundwater for all domestic and agricultural purposes. For this receptor, eating and drinking habits were estimated from the regional survey and all food was locally produced. As previously indicated, the regional survey did not identify any resident of the area who had these specific characteristics. (page 9-39)

2.4 Comments and Conclusions

To determine whether a repository complies with a given regulatory standard, a compliance assessment must calculate the dose (or risk) to some individual or a specific group of individuals and then compare the results to the dose (or risk) limit established in the standard. For an existing standard, the dose (or risk) limit has been defined for a specific individual or group for whom protection is sought. EPA standards traditionally employ the reasonable maximal exposed individual (RMEI). Accordingly, compliance assessment for Yucca Mountain would dictate the need to employ RMEI as its receptor. However, the EPA has yet to finalize a standard for Yucca Mountain and the NAS Committee had recommended the probabilistic critical group and/or the subsistence-farmer critical group as potential receptors.

The TSPA-VA defines three separate receptors who are alternatingly referred to as the "critical group." None of these receptors fits the definition of the critical group as given by the ICRP or the probabilistic critical group described by the NAS Committee. Clearly, the following TSPA-

VA statements (in behalf of the 452 current households in the Amargosa Valley) do not provide a basis for future compliance assessment: *"The average Amargosa Valley resident is used in the TSPA-VA to provide an estimate of the expected exposure"* or *"...from the perspective of those people who presently reside in the region, the average individual provides the best estimate for future exposures"* [emphasis added] (page 9-27).

From the viewpoint of satisfying a future EPA Yucca Mountain standard, a reasonable conclusion is that the TSPA-VA's subsistence farmer receptor would most likely satisfy the Agency's criteria for the RME individual.

3.0 SECTION 2: ASSESSMENT OF BIOSPHERE MODEL PARAMETERS

The biosphere model used in the TSPA-VA employs the GENII-S code, which is a successor to the GENII Pacific Northwest Laboratories code. Developed by Sandia National Laboratories, the GENII-S was designed for use in the performance assessment of the Waste Isolation Pilot Plant (WIPP). The GENII-S system includes interactive menu-driven programs that assist with scenario generation and data input requirements. Input requirements for each parameter value may then be selected from data libraries or other sources including site-specific information.

The selection of TSPA-VA model parameters was critically reviewed for appropriateness and/or consistency with Yucca Mountain demographics and environmental conditions. All but two model parameters appear to have employed values considered appropriate. Presented below is a discussion of the two TSPA-VA parameter values considered inappropriate.

3.1 Food Intake

Section 9.4.4.2 describes the approach used to estimate intake quantities of food by each of the three receptors. The GENII-S code requires estimates of annual consumption of selected foods in terms of mass. Quantitative data for food intake could not be extracted directly from survey data of the population within 84 km of Yucca Mountain. Survey data, however, did provide "consumption frequency" for major food categories which was then combined with USDA data. Table 1 provides the yearly food consumption quantities of "locally produced" foods for the subsistence farmer and resident farmer.

Data presented in Table 1 suggest that the subsistence farmer, who derives 100% of all food from home-grown/local sources, consumes an average value of 1,079 calories per day. (The caloric intake for the resident farmer is identical to that of the subsistence farmer, except that only 50% of the food is from home-grown/local sources.)

Table 1. Calories Consumed by Food Intake

Food Category	Best Estimate of Annual Intake of Locally-Grown Food			Annual Calories Consumed	
	Subsistence Farmer	Resident Farmer	Avg. Calories/Kg[1]	Subsistence Farmer	Resident Farmer
Leafy Vegetable	63.55	31.78	300	19,064	9,532
Other Vegetables	28.86	14.43	1,000	28,860	14,430
Fruits	59.32	29.66	800	47,456	23,728
Grain	60.64	30.22	375	22,740	11,370
Beef	38.97	19.49	3,000	116,910	58,455
Poultry	15.74	7.87	2,500	.39,350	19,675
Milk (liters)	136	68	680	92,480	46,240
Eggs	16.67	8.34	1,620	27,005	13,503
		Total Annual Calories		393,865	196,932
		Average Daily Calories		1,079	539

[1] Source: Hawk's Physiological Chemistry (Hawk 1965)
Calorie Tables are included as Appendix A.

The average daily caloric intake (and hence the average daily intake of food) is low by at least a factor of three. Table 2 cites an energy expenditure of 3,200 calories per day for the 70 kg Reference Man (ICRP 1975). Moreover, even the 3,200 calories per day for Reference Man would appear low. For example, 1,200 calories per day for Reference Man represent 8 hours of light work that mostly involves standing. For subsistence farming, the TSPA-VA model assumed 15 hours per day of outdoor farming activities (see Table 9-21 of TBD). If subsistence farming activities are per unit calorically-equivalent to "domestic work" defined in Table 2, then the 15-hour workday of the subsistence farmer is represented by 4,700 calories. If the 9-hour balance of time were to include 8 hours of bed rest at 500 calories and 1 hour of washing,

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dressing, eating, etc. at 180 calories, the daily caloric requirement of the subsistence farmer is estimated at about 5,400 calories per day or about 5 times the daily caloric food consumption rate allotted in the TSPA-VA biosphere model.

Table 2. Energy Expenditure of Reference Man[1]

Daily Activity	Cal/day	Cal/day
8 hr light working activities: mostly standing (overall rate, 2.5 kcal/min)		1200
8 hr nonoccupational activities:		1500
1 hr washing, dressing, etc., at 3 kcal/min	180	
1.5 hr walking at about 6 km/hr at 5.3 kcal/min	480	
4 hr sitting activities at 1.54 kcal/min	370	
1.5 hr active recreations and/or domestic work at 5.2 kcal/min	470	
8 hr rest in bed at BMR		500
Total		3200

(1) Source: ICRP 1975.

On the basis of caloric intake requirements, the contribution to dose by contaminated food products as estimated in the TSPA-VA is low by a factor of 3 to 5.

3.2 Location of the Critical Receptor

In the TSPA-VA, the subsistence farmer was characterized and modeled as the individual most likely to receive the highest dose among individuals of the exposed population. Due to the likelihood of future subsistence farming in the vicinity of Yucca Mountain, it may be further assumed that the subsistence farmer satisfies EPA's criteria for the reasonable maximal exposed individual (RMEI). At Yucca Mountain, however, the qualification of the subsistence farmer as the RMEI is conditional. Of critical importance is this individual's physical location to the repository relative to other members of the exposed population. Based on relative proximity to the proposed repository, EPA's RMEI could conceivably be represented by a commercial farmer, a rural resident with a home garden, or someone simply using contaminated ground water for domestic uses.

For example, a subsistence farmer who derives all drinking water and home-grown food from contaminated ground water at a location 20 km from the repository may be exposed to lower doses than persons whose exposure pathways are limited to drinking water or fractional quantities of contaminated home-grown food products but who reside at locations that are much closer to the repository boundary. This is because contamination levels in ground water are assumed to decrease with increasing distance from the repository boundary.

Numerous geophysical restrictions and economic factors are likely to affect the probable location and distribution of future individuals within the exposed population. For example, slope of terrain and poor soil quality are factors that could potentially preclude farming but not rural residency very near the repository boundary. Alternatively, the probability of a commercial farm near the repository boundary may be envisioned in a case where the one-time high cost of drilling a deep well can be economically justified for commercial farming but not subsistence farming and/or rural residency. The availability and cost of extracting ground water may also affect the type of farming. While some farming in a desert environment would require extensive use of ground water, certain highly specialized farming (e.g., ostrich farming or hydroponic farming) requires only modest amounts of water.

The NAS Committee on Technical Bases for Yucca Mountain Standards recognized the potential for excess conservatism if the potential critical group was defined as individuals engaged in subsistence farming at a location just outside the footprint of the repository. Accordingly, the Committee recommended a probabilistic approach for future population distribution and human activities that were based on actual environmental parameters such as (1) depth to aquifer, (2) soil quality, (3) land slope, and (4) growing season. Under this approach, the probability that persons occupy specific parcels of land for farming is "*. . . determined statistically by the relevant characteristics of the land, groundwater, and technology that influence farming, avoiding the potential that the standard [or the compliance assessment] could be influenced by a situation in which the maximum dose occurred at a place that was uninhabitable or otherwise unsuitable for farming*" (NAS 1995, page 101).

Chapter 9 of the TBD provides biosphere dose conversion factors (BDCFs) for each of the three receptors in behalf of 39 radionuclides. The BDCFs have dimensions of millirem per year per picocurie per liter of ground water. Thus, the derived BDCF values are based on contaminants being present at unit concentration and are, therefore, independent of the future location(s) of the receptors and actual contaminant levels of ground water.

However, the biosphere description in Chapter 9 of the TBD refers to a "20 km distance" (page 9-27) from the repository site as the likely location for actual estimates of dose(s) needed for compliance assessment.

The selection of this distance (i.e., 20 km) appears to have no defensible technical basis such as the approach proposed by the NAS Committee in Appendix C. It appears to have been selected on the basis of current population demographics: *"The nearest community in the direction of flow of groundwater is Amargosa Valley.... Within this district the closest inhabitants to Yucca Mountain are approximately 20 km (15 mi.) south at the intersection of US 95 and Nevada State Road 373, in the community of Lathrop Wells"* (page 9-1).

The choice of the 20 km distance from repository site to the critical receptor cannot be justified given the long time period between repository closure and potential future exposures. The likelihood of substantially underestimating exposure to the critical receptor becomes obvious from current information and trends that define the recent past for Nye County. The following are excerpts taken from the 1993 Nye County development plan (Nye 1993).

Land Use and Zoning

At the present time, there is no zoning in Nye County. . . . Land use on private lands in Nye County consists of residential, commercial, and industrial uses, largely but not exclusively within the boundaries of unincorporated towns, and agricultural uses both within and outside the boundaries of unincorporated towns. There is no inventory of the amount of land in each land use category, because in the absence of mechanisms to regulate land use, much of the land within communities is subject to mixed use. It is common to find residential, commercial, industrial, and even agricultural uses on adjacent properties and, at times, on the same parcel of property.

Population

According to [U.S. Census Bureau], Nye county grew from 3,606 in 1940 to 17,781 in 1990, an increase of almost 500 percent in 50 years. Even more remarkable, Nye County population virtually doubled in the last 10 years. To illustrate the importance of this phenomenon, if Nye County were to grow at the same growth rate for the next 50 years as it has over the past 10 years, Nye County population would exceed 500,000 people in the year 2040! While there are a number of very important prerequisites (e.g., economic growth, water, transportation networks, etc.) for such a sustained high rate of growth to occur, it is instrumental to note that Clark County (primarily the Las Vegas Valley) grew *from under 17,000 to over 700,000 during the last 50 years. It is doubtful that in 1950 even the most optimistic of visionaries would have been able to predict Las Vegas's explosive growth.*

The current nearest resident at 20 km from the proposed site is not a defensible distance for assuming upper bound future exposure(s) needed to demonstrate regulatory compliance.

4.0 REFERENCES

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APPENDIX G

USE OF COMPUTER CODES IN THE TSPA-VA

USE OF COMPUTER CODES IN THE TSPA-VA

1.0 SUMMARY

Information included in the Viability Assessment (VA) documents concerning computer codes that were used to perform the TSPA-VA analyses is quite limited. Brief descriptions of principal codes that were used are provided in the TSPA-VA document, Volume 3 of the VA report (DOE 1998a). Chapter 1 of the Technical Basis Document (DOE 1998b) observes that details of the TSPA code architecture and the methodology associated with the sensitivity and uncertainty analyses were not included in Volume 3, and that the purpose of the Technical Basis Document is to provide the details. This review found, however, that the information provided was not sufficient for clear understanding of the codes and their use in the TSPA-VA.

Table 1 lists 30 programs that were utilized to develop the TSPA-VA. These 30 programs were found at four locations within the TSPA-VA backup documentation: Tables 8-3, 11-2 and 11-4, and Figure 11-4 (TSPA-VA, Figure 2-13). The Table 1 listing of computer program is not an all-extensive list of programs used in the TSPA-VA; rather, it lists only the *more important* programs that were used, and demonstrates the large number of programs employed.

Table 1 also briefly describes the programs and their quality assurance status. The quality assurance status is given as "Q" for programs that have been placed under the YMP's QA program, "NQ" for programs that are not currently under the YMP's QA program, or "NQ/Q" for programs that are not under the YMP's program but have undergone formal quality assurance by the program's author.

The executive driver program or integrating shell that links all the various component codes is RIP Version 5.19.01 (Golder Associates, Inc. 1998). This is a probabilistic sampling program that ties all the component models, codes, and response surfaces together in a coherent structure that allows for consistent parameter sampling among the component models. The RIP program is used to conduct either single-realization runs of the entire system or multi-realization runs of the system. The latter realizations yield a probability distribution of dose rate in the biosphere that shows uncertainty in dose rate based on the uncertainty in all the component models.

Table 1. Partial List of Computer Programs Utilized in the TSPA-VA

Program	Purpose	QA*
3DADE	Analytical solution for 3-D solute transport. (Table 8-3)	NQ
ARC/INFO	Geographical database & visualization: Flow models. (Table 8-3)	NQ
CLAD_DEG	Cladding degradation, not found in the text. (Figure 11-4)	—
EDC	RIP callable, effective UZ diffusion coefficient routine.	NQ
EQ3/6	Near-field geochemical environment (Figure 11-2)	Q
FEHM; FEHMN	Particle tracking groundwater transport. (Figure 11-4)	NQ
GENII-S	Dose factor calculations.	NQ/Q
GEOMESH	USGS site-scale flow model. (Table 8-3)	NQ
GLDiss	RIP callable, glass dissolution routine. (Table 11-4)	NQ
INFIL	Surface infiltration, not found in the text. (Figure 11-4)	?
ITOUGH2	Inverse version of TOUGH2. (Figure 11-4)	NQ
MODFLOWP	USGS regional-scale flow model. (Table 8-3)	NQ/Q
NUFT	Thermal-hydrology (Figure 11-4)	NQ
PEAKCONTR	Radionuclide contribution to peak dose rate. (Table 11-4)	NQ
PEAKTIME	Extract time of peak-dose rate from RIP output. (Table 11-4)	NQ
PEST	USGS site-scale flow model. (Table 8-3)	NQ/Q
POSTCON	TSPA 1-D transport model output post-processor. (Table 8-3)	NQ
PRESATOOL	Uncertainty/sensitivity, preprocessor for SATOOL (Table 11-4)	NQ
READPCC	Extract partial correlation coefficients from SATOOL output.	NQ
RIP	Executive driver. (Figure 11-4)	Q
SATOOL	Uncertainty/sensitivity, perform regression analysis. (Table 11-4)	NQ
SFDiss	RIP-callable, spent fuel dissolution routine. (Table 11-4)	NQ
SGSIM	Statistical simulation of heterogeneous permeability. (Table 8-3)	NQ/Q
SISIMPDF	Statistical simulation of heterogeneous permeability. (Table 8-3)	NQ/Q
STATISTICA	SZ parameter statistical analysis. (Table 8-3)	NQ
STRAIAMODEL	USGS regional- & site-scale flow, and TSPA 3-D flow.	NQ
STUFFIT	Insert zero peak-dose rates into RIP output. (Table 11-4)	NQ
SZ_CONVOLUTE	RIP subroutine in TSPA-VA calculations. (Table 8-3)	NQ
TOUGH2	Flow field calculation. (Figure 11-4)	Q
WAPDEG	Waste package degradation. (Figure 11-4)	NQ

*
Q — under the YMP's QA program
NQ — not currently under the YMP's QA program
NQ/Q — not under the YMP's program, but has undergone formal quality assurance by the program's author

The RIP total system integrator has the capability to call external routines. These are stand alone programs that are *linked* to RIP at run-time (*i.e.*, dynamically linked) via a pre-defined protocol. The TSPA-VA has taken advantage of this capability by linking a number of external computer routines (programs) to RIP, including SFDiss, GLDiss, EDC, FEHMN, and SZ_CONVOLUTE.

In Table 11-4 of the TSPA-VA backup documentation, SZ_CONVOLUTE is indicated as having been quality assured, while on Table 8-3 it is indicated as not having been quality assured.

The TSPA-VA discusses two versions of the Finite Element Heat and Mass (FEHM) transfer program: FEHM and FEHMN (FEHM Nuclear). Figure 11-4 in the backup documentation indicates that FEHMN was used, while TSPA-VA, Figure 2-13, shows that FEHM was used. Dr. G.A. Zyvoloski of Los Alamos National Laboratory (one of the authors of FEHM) was contacted to explain the differences, if any, between FEHM and FEHMN. Dr. Zyvoloski stated that originally the YMP had intended to differentiate between the FEHM program that was available to the general public and the version thatthe YMP used (*i.e.*, FEHMN). LANL did not agree with the concept of having two versions of FEHM (perhaps because it would be difficult to keep track of which features were contained within which program). Presently, there is only one version of FEHM which is used by both the general public and the YMP, and refering to FEHMN is synonymous with FEHM.

FEHM has undergone extensive QA at LANL; however, it has not been quality-assured under the YMP's procedures (see Table 11-4). This is particularly important for the version of FEHM that was modified to operate as a RIP-callable subroutine.

Both TSPA-VA, Figure 2-13, and backup documentation Figure 11-4 show that a computer program called CLAD_DEG was used to model "cladding degradation." However, CLAD_DEG is not discussed anywhere in Section 6 of the backup documentation, or in the TSPA-VA. Instead, Section 6.1.1.3 (and elsewhere) indicates that the Waste Package Degradation Model (WAPDEG Version 3.07) was used to simulate the generalized and localized corrosion of the Zircaloy cladding for commercial spent nuclear fuel, as well as to simulate waste package degradation.

Likewise, both TSPA-VA, Figure 2-13, and backup documentation Figure 11-4 show that a computer program called INFIL was used to model "surface infiltration." However, INFIL is not discussed anywhere in Section 2.4.2, "Infiltration", of the backup documentation.

Three different versions of WAPDEG were used for the analyses presented in the TSPA-VA. The base case analysis was conducted with Version 3.07, and the sensitivity analysis was conducted with Versions 3.09 and 3.11. Different versions were used because the code was continuing to develop to meet the needs of various sensitivity analyses. The different WAPDEG versions were baselined and reproducible, but were not fully qualified. This is reasonable at this stage of the project, since WAPDEG is continuing to be developed.

While in Table 1 EQ3/6 appears to be a single program, it is in fact a package of programs and consists of a number of codes, including EQ3NR and EQ6. Version 7.2b of the EQ3/6 code package was used. This is a Quality Assurance (QA) version of the program, which is under Configuration Management control, and was installed and tested following the Computer Software Qualification Procedure, QAP-SI-03.

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ATTACHMENT C

CLARK COUNTY COMMENTS ON TRANSPORTATION SECTIONS OF THE U.S. DEPARTMENT OF ENERGY'S DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

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1.0 Introduction

224 This report describes problems in the areas of transportation and emergency management identified by Clark County, Nevada in its review of the Department of Energy's Draft Environmental Impact Statement for the Yucca Mountain Project (DEIS). There are substantive problems with the DEIS in both the areas of completeness and sufficiency. A careful review of the DEIS reveals that despite the thoroughness with which some of the necessary information has been collected, there is very little analysis and interpretation of what the information means.

The Department of Energy's (DOE) Yucca Mountain Program has been substantively criticized over a long period. These criticisms (notably in the comments to the 1986 Environmental Assessment and the Waste Management Programmatic EIS) led the DOE to promise that the Yucca Mountain EIS would address issues raised in the past. These substantive criticisms have not been addressed by the DEIS. New concerns have been raised by the DEIS' inadequacies.

This report describes Clark County's major concerns with the DEIS as they relate to transportation and emergency management. The report begins by describing crosscutting criticisms that are not related to a specific impact. Next, the report summarizes areas of primary concern to Clark County. Following this summary, the report provides extended comments on each of the concerns.

Crosscutting Problems with the DEIS

225 The DOE made certain assumptions and adopted procedures in preparing the DEIS that exert their influence throughout the DEIS. These assumptions and procedures are described here as crosscutting problems. Although they do not specifically apply to each issue, crosscutting issues are identified here are problems that many portions of the DEIS.

The DOE adopted a peculiar strategy in preparing the DEIS. Ignoring thirty years of best practice in the preparation of Environmental Impact Statements, the DOE chose to adopt the narrowest possible definition of impacts. By narrowly defining what an EIS is and what an EIS is supposed to do, the DOE ensured that it found no impacts. The transportation analysis is emblematic of this approach. The DEIS did not study traffic impacts that are normally considered by an EIS. Congestion, lane widths, shoulder widths, peak hour traffic, roadbed conditions, and other conventional measures of traffic impacts are ignored. By narrowly defining impacts as solely radiological health impacts this ensures no substantive impacts will be identified by the DEIS. Another example is the emergency management section. By insisting that the DEIS is not an emergency planning document, the DOE avoided preparing any estimates of the costs necessary to mitigate the impacts of emergency response. This approach to impact assessment is consistent with other DOE impact assessments (notably the Nevada Test Site EIS), but does not conform to best practice in the field of impact assessment. While this approach may have facilitated speedy preparation of the DEIS, it did not result in a thorough analysis of the impacts of the program and violates the letter and spirit of NEPA.

226... The purpose of an EIS is to establish a basis for mitigation negotiations. To achieve this goal, an EIS must assign specific roles and responsibilities for actions, which cause impacts, as well as those which ameliorate impacts. The DEIS fails to provide this information. For example, there is no information about how an "implementing alternative" for a route through Nevada will be chosen, when construction will begin, what agency will oversee the construction, and how the route will be maintained. Clark County, and other effected jurisdictions do not have sufficient

26 cont, information necessary to understand potential impacts. The DEIS should have selected an "implementing alternative" to move waste through Nevada. It should have provided a specific schedule for the construction of a route to Yucca Mountain. The DEIS should have defined specific agency responsibilities for constructing, maintaining and operating the route to Yucca Mountain. None of this has been accomplished. Indeed, none of the information necessary to describe how an implementing alternative will be selected is provided in the DEIS.

227 Recent years have seen an increased interest in risk assessment approaches that better characterize and quantify uncertainty. The National Academy of Sciences has stated that "Whenever possible, (upper bound potency estimates) should be supplemented with other descriptions of cancer potency that might more adequately reflect the uncertainty associated with the estimates." The National Research Council has made a similar call for a characterization of uncertainty. The DEIS' risk estimates are presented as authoritative estimates of risk. The large degree of uncertainty in the estimates is left unstated. In order for the DEIS to have credibility with the public and policymakers, the DOE should have pursued an assessment strategy that quantified uncertainty rather than ignored it.

228 The quality of the report is flawed in fundamental ways. Sources cited by the report in Chapter 6
refer to reports that assumed the use of a Multi-Purpose Canister (MPC) system. The DOE has
abandoned the MPC system as unworkable. Despite this, the DEIS uses references about the
MPC design to support its conclusions. The references cited by the DEIS are not relevant for the
229 proposed action described by the DEIS. The data used to support the conclusions of the report is
also questionable. The DEIS relied on 1990 Census data to estimate the health effects of
transporting spent fuel. Detailed comments later in this report describe the seriousness of this
230 underestimate. Other data is also apparently flawed. In 1998, Clark County received geographic
data files from DOE. These data files were for the proposed implementing alternatives through
Nevada to Yucca Mountain. Cartographers from Clark County's Geographic Information
Systems Department found that the files provided by the DOE incorrectly located major features
595 (e.g. Interstate 15). Maps presented in the DEIS are also fundamentally misleading. No national
routes are depicted in the report. Many of the people who are most affected by the program will
596 not be aware of the impact based on the report's contents. The DEIS' maps fail to depict urban
Clark County properly. The maps in the DEIS give the incorrect impression that a route using the
beltway does not pass near urban Clark County. The maps in the DEIS depict Las Vegas as a
small point, without depicting all of urbanized Clark County. All of these concerns contribute to
the impression that the report was prepared in an amateurish way that disregarded the most basic
standards for research.

Areas of Concern to Clark County

This section of the report summarizes Clark County's major concerns in the areas of transportation and emergency management. This is by no means a definitive list. This list was developed after a careful review of the document and lengthy study. If more time is available, additional concerns will be raised about the document. These bulleted points are not listed in order of importance these are major flaws in the DEIS:

231 ▪ The assessment of the risks of transporting spent fuel is not credible because the equipment proposed to transport and handle the waste does not exist. The reference materials provided in the DEIS indicate that no actual equipment exists for transporting, storing and handling the Spent Nuclear Fuel. There are only "preliminary sketches" of the equipment.

232... ▪ The DEIS is insufficient because it does not present any information about the operation of the transportation system. In other documents, DOE identified the following components of

232 the system: Design, Development, Certification, Testing, Acquisition, Operation of all necessary transportation equipment and services. By failing to describe these critical systems, the DOE has failed to provide a credible EIS that assigns responsibilities and provides sufficient information to negotiate mitigation. Basic questions about the program are not answered (e.g. how many casks will be built? What is the lifetime of a cask? When will they be built? When will the trailers for trucks and the rail cars be fabricated? What are the testing standards for them? Will they be road tested first? Will the waste packages be opened and the waste inspected before it is disposed? Will the waste be shipped in a single container with multiple uses, or will waste be transferred from a shipping container to a disposal container? If so, where will the facility to perform such an operation be located? When will it be built? By whom?).

233 ▪ The DEIS does not provide a thorough description of intermodal handling operations. What are the risks of cask handling at intermodal sites? Does cask-handling equipment exist? Has it been tested? Who will test it? When? When will a decision about intermodal site selection be made?

234 ▪ The DEIS is insufficient because it should have selected a route through Nevada to the proposed Yucca Mountain Facility. At least, the DOE should have described the process of selecting an implementing alternative. In 1995, the DOE reported that route evaluation criteria for the various transportation routes would be described in the DEIS. Nowhere does the document provide any description of how and why the DEIS will select the route evaluation criteria, how and when they will be applied and when the final route decision will be made. This is especially important in light of the DOE's decision to list the "Chalk-Mountain" route as non-preferred because of the objections of the Air Force. The DOE must explain why the Air Force was effectively granted veto authority over routes through Nevada.

235 ▪ The DEIS assumes a single route strategy for national transportation-there is no comparison of truck or rail alternatives-e.g. for the current regulations and an alternative strategy. The DEIS does not describe the effects of transporting waste through the following corridor communities: Nashville, Atlanta, Chicago, Omaha, Denver, Dallas, and Salt Lake City. The DEIS is also insufficient because it fails to define which communities are in fact corridor communities. The DEIS should have provided a measure of the volumes of waste that will travel on each route.

236 ▪ The DEIS does not analyze the full range of modal alternatives. Specifically, the DEIS fails to analyze the risks of heavy haul transportation. Despite the DOE proposal to use heavy haul transportation on congested freeways through densely urbanized areas of northern and western Las Vegas.

237 ▪ The DEIS should have indicated how human health risk will enter into decision-making because human health risk was the only risk evaluated in the DEIS. Based on the contents of the DEIS, risk assessment is not a worthy decision-making criteria. A comparison with the Generic EIS prepared by the Nuclear Regulatory Commission (NRC) for the licensing of nuclear power plants is instructive because it highlights the methodological inconsistencies in transportation risk assessment. The DEIS should explain how risk will be used and how it
238 can be compared. The DEIS provides no basis for comparing routes within Nevada.

239 ▪ The DEIS failed to credibly address problems of security and terrorism. Security problems should have been prominently discussed. The only discussion of the issue was confined to the cursory refutation of arguments made by the State of Nevada. No discussion of eco-terrorism, civil disobedience, or the diversion of military equipment was included.

240 ▪ Despite overwhelming evidence and fifteen years of commentary, the DOE failed address the impact of human factors and institutional arrangements on risk. The DOE has ignored the most likely cause of a catastrophic accident.

241 ▪ The DEIS fails to examine the likely interaction of the Yucca Mountain Program on other Federal activities in Nevada. For example, Clark County is non-attainment for National Ambient Air Quality Standards (NAAQS). The DEIS does not analyze the effect construction of the Heavy Haul infrastructure improvements or a rail line will have on the Regional Transportation Plan.

242 ▪ The DEIS proposes an unprecedented program of waste transportation. However, the record of previous transportation shipping campaigns is not encouraging. The DEIS should have provided a forecast of likely accidents.

243 ▪ The DEIS examines only the problem of transporting 25 year old spent fuel. It is likely that younger, more radioactive fuel will be shipped to the Yucca Mountain facility. The DEIS should have examined this likelihood by bounding its analysis between 10 year and 25 year old spent fuel.

244 ▪ The DEIS grossly understates the human health risk of transporting spent fuel by using the 1990 Census data.

245 ▪ The DEIS fails to address the impacts on Clark County caused by the program. For example, what will be the traffic effect of a 300-foot long convoy carrying spent fuel, moving along a highly congested freeway four times a day for 24 years? The DEIS is mute on the most likely and reasonable impacts of the transportation program.

246 ▪ The software used to analyze transportation risk in the DEIS was RADTRAN version 4.019. Extensive criticism of RADTRAN has been made in other venues. Although courts have allowed RADTRAN's analysis of risk, the many shortcomings of this approach should be examined in the DEIS. In particular, the DEIS should have provided the full RADTRAN outputs and interpreted their meaning. A portion of these outputs would have been the decontamination costs should an accident occur.

247 ▪ The strategy used to examine environmental justice impacts of the Yucca Mountain program is deeply flawed when compared to practices adopted by other federal agencies. The DEIS should have implemented a credible environmental justice program.

248 ▪ Of critical concern when examining the impacts of spent fuel transportation is the impact of a likely accident. The DEIS is insufficient because it fails to provide a clear description of the Maximum Reasonably Foreseeable Accident (MRFA). It fails to analyze the costs to mitigate that accident. It fails to examine the cost to recover from that accident. The DEIS fails to describe the equipment, personnel, and facilities necessary to respond to the accident.

249 ▪ Congress has directed that localities affected by the Yucca Mountain Program be provided with funding to prepare emergency management assets for the program. The DEIS should have examined the institutional arrangements necessary to provide emergency response assistance to affected localities. The DEIS should have assigned specific roles and responsibilities for various federal agencies (such as the Federal Emergency Management Agency).

250 ▪ There are conflicts between the proposed action analyzed by the DEIS and plans in Clark County, Nevada. The DOE's examination of these impacts was cursory and must be revised.

251 ▪ The description of cumulative effects used by the DEIS is incorrect. The effect of the DOE's Low Level Radioactive Waste (LLW) disposal program at the Nevada Test Site on the Yucca Mountain Program is unaccepted.

Extended Comments

The following sections provide extended comments on the major concerns cited above.

Performance Data and Uncertainty

252 The risk assessment presented in the DEIS is not supported by relevant empirical data. The cask handling equipment, the cask truck trailers, heavy haul equipment, and waste casks do not exist. There is no empirical data to support DOE's claims about the validity of their risk assessment. Experience shipping spent nuclear fuel may or may not be relevant for the proposed action.

253 In previous years, SNF has primarily been shipped only in sporadic, carefully managed campaigns that do not reflect the scope and complexity of the Proposed Action. Seasonal shipping schedules are not considered. SNF has only occasionally been shipped during winter. If DOE decides to move waste only during summer months then the numbers of shipments will increase along with radiation exposure along the routes. Whether the waste is shipped in individual trucks or in convoys of trucks will also affect radiation dose. Waste shipped as general freight on railcars or via dedicated train will have the same effect on dose rates. A major source of incidents occurs in handling waste containers. Several of the DEIS' Implementing Alternatives call for intermodal shipment of waste on a larger scale than has ever been done. For example, from the Brown's Ferry reactor site, there may be over 48 truck shipments per year for the duration of the proposed action. This means that almost 200 fuel assemblies must be retrieved, moved to waste casks, and shipped each year.

254 This unprecedented high level of handling activity has never taken place before. Handling at an intermodal facility is just as problematic. There is no accident or incident data describing likely accidents handling spent fuel at intermodal facilities. A major cause of concern is the use of historical accident rates to describe the risks of a roadway not yet constructed. The DEIS assumes that the mostly truck alternative will use Clark County's

northern and western beltways to transport spent fuel. These roads have not yet been constructed and there is no empirical data about accidents on these roadways.

255... The DEIS argues that the risks of transporting wastes for the Proposed Action and Modules 1 and 2 can be understood based on past HLW shipping experience. Clark County believes this assumption is incorrect. The DEIS assumes that because SNF has been shipped for 30 years without a Latent Cancer Fatality (LCF) attributable to the shipping, it is possible to make inferences about the risks of the Proposed Action and Modules 1 and 2. Clark County believes that the length of time during which SNF shipments have been made is immaterial to the proposed action in the DEIS. Other measurements provide a better indication of the experience we possess in transporting SNF.

From 1964 to August 1990, only 2,581 shipments of 2,667 cask loads of commercial SNF were transported. The Proposed Action calls for 37,773 mostly truck shipments while Modules 1 and 2 will require 66,595 mostly truck shipments. Twenty-six years of experience transporting SNF amounts to only six percent of the shipments called for by the Proposed Action. However, 255 cont. comparing the number of shipments is less revealing than comparing the number of shipment miles between experience and the proposed action.

Figure 1 compares the shipment-miles for spent fuel in the 1971-1990 period to the shipment miles for the Proposed Action and Modules 1 and 2. Clark County believes the great disparity in numbers suggests that any reliance on previous history is extremely problematic.

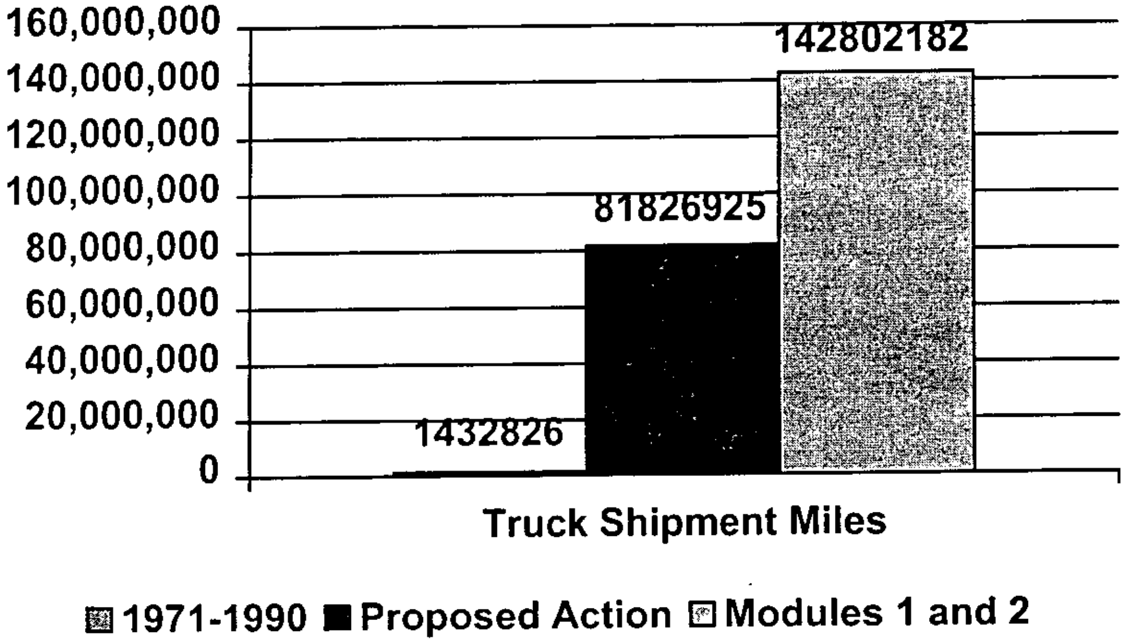

Figure 1 Past SNF Truck Shipment Miles and Proposed Shipment Miles

256 The greatest cause for concern is the absence of operational performance data for most of the complex packaging, handling and shipping equipment required to implement the Proposed Action and Modules 1 and 2. For example, the GA-9 transportation cask is one of the primary components of the waste handling system envisioned in the DEIS. However, that cask requires a special trailer to handle and transport. This trailer has not yet been constructed. As was noted in one of the reference documents supplied with the DEIS, only "preliminary sketches" exist. This problem is particularly acute for the heavy haul transportation proposal. No data are presented in the DEIS to support any conclusions about the safety of transporting a 125 ton cask twice daily at 25 mph on an urban bypass with posted speeds of 65mph through Clark County. No past experience, transporting spent fuel is relevant to the proposed action because there is no operational performance data for the equipment used to handle the waste.

257 One of the primary reasons this examination is confined to truck analysis, is because the heavy rail casks assumed to be used in the DEIS do not exist at all. Several of the DEIS references were prepared assuming use of the Multiple Purpose Canister (MPC). The MPC was proposed by the DOE as a heavy transportation canister in 1994. It was later withdrawn after the preparation of an EIS. The reference documents cited to support the conclusions in the DEIS rely on the MPC canister for their conclusions. Therefore, the rail transportation scenario contained in the DEIS is almost entirely hypothetical. Past rail transportation experience, specifically data used in a risk assessment is wholly irrelevant to the proposed action.

258 The claim made in the DEIS is that the impacts of transporting SNF to Yucca Mountain can be understood based on past experience, and that experience suggests that the risks are low. Experience is not an adequate indication of the true risks of transporting nuclear waste. The transportation system needed to implement the Proposed Action in the DEIS is so complex, extensive, and different from anything that has occurred in the past, that previous experience is not a suitable guide. However, even when limited, flawed past experience is used to predict the anticipated performance of the DOE transportation system, the conclusions can be troubling.

Types of Incidents

259... Reports on incidents involving the transportation of radioactive materials are contained in the Radioactive Material Incident Report database maintained by Sandia National Laboratories. There have been 72 incidents involving transporting radioactive materials between 1949 and the present. The 72 incidents can be characterized as follows:

- 4 incidents of accidental radioactive material contamination beyond the vehicle
- 4 incidents of accidental radioactive material contamination confined to the vehicle
- 13 incidents of traffic accidents, resulting in no release or contamination
- 49 incidents of accidental surface contamination
- Two other incidents were mentioned in papers but descriptions are not available.

Eight incidents of radioactive material contamination (between 1960-1984) involved leaks of water, liquid, or (reported as) coolant/moderator from casks which were discovered during shipping. Description of the events and equipment are insufficient to evaluate the failure mechanisms or sources of contamination.

Incidents in Clark County

Based on the numbers of past incidents and the number of shipment miles, it is possible to estimate the types of incidents that can occur in Clark County. For this examination, nine rail incidents are excluded from the 72 total incidents. Based on numbers in the DEIS seven percent of all shipment miles in the mostly truck scenario would take place in Clark County. The proportion of incidents that have occurred in the past and the inferred incidents is listed below:

Type of Incident	Number of Historical Truck Incidents	Percentage of Total Incidents	Estimated Number of Incidents in Clark County for the Proposed	Estimated Number of Incidents in Clark County for Modules 1 and 2

			Action	
Radioactive material contamination beyond the vehicle	3	5%	3	5
Radioactive material contamination confined to vehicle	3	5%	3	5
Transportation accident. no release or contamination	7	11%	7	12
Surface contamination	48	76%	46	81
Unknown	2	3%	2	3

Figure 2 Estimated Incidents in Clark County

259 cont. Based on this partial examination, the DEIS should have anticipated some of the likely failures identified above and described how those failures will be mitigated and repaired.

Transportation System Description

260 The DEIS is insufficient because it fails to provide any description of the complex system that will be needed to transport SNF on the scale proposed in the DEIS. Without such a description, an assessment of the impacts of transporting waste is impossible. DOE has recognized the importance of this problem in the past, but has not addressed it in the DEIS. In previous documents, DOE identified the following components of the transportation system: Transportation Cask Systems, Service and Maintenance Support, Field Operations, and Planning and Control.

Substantial questions are raised in the DEIS but not answered. The response of the DOE to questions about the system used to move waste from origin sites to the final repository has been that there are many unknowns in the transportation system and that final study of the system requires determination of site suitability. There are two problems with this argument.

First, is that the information contained in the DEIS will be used by Congress to make decisions about the disposal program. By presenting admittedly piecemeal and incomplete information, the DOE opens itself to charges that it was disingenuous with Congress and the American people. The DOE should remedy this problem by clearly labeling those areas in the DEIS where the information is untrustworthy and incomplete. The second flaw in the DOE's argument is that it assumes that once the site is selected, it will be possible to transport the waste. By failing to provide a comprehensive, credible study of the transportation system, the DOE gives the misleading impression that only site characterization is an important issue. In other words, only site characterization is a relevant issue. Given the quality of the DEIS' analysis, this does not seem likely. Comments in this area will relate to each of the functional transportation system areas identified by the DOE. Due to the paucity of information in the DEIS, these comments are largely posed in the form of questions. The following paragraphs describe the system components.

261 *Transportation Cask Subsystems*

Design of the transportation equipment, as well as the institutions that will manage it has only begun. The equipment necessary to transport and handle the waste does not exist. Some of the equipment has been designed and licensed by the NRC, but none of this equipment has ever been built or used to transport SNF. There is no data about the safety performance of the equipment. The reference materials provided in the DEIS indicate that no actual equipment exists for transporting, storing and handling the Spent Nuclear Fuel.

262 *Cask Fleet*

No safety performance data exist to provide the basis for a credible transportation risk assessment. How many casks will be built? How long will a cask be used? When will they be built? Once a design is selected, how will it be tested? Will the tests be full-scale or models? How many spare parts will be fabricated? When? When will they be tested? How will changes to cask design be performed? How will the Regional Service Companies (RSCs) manage the spare parts and the cask fleets? None of these questions are addressed by the DEIS.

263 *Specialty Casks*

A fundamental advantage of intermodal handling is to reduce accidents through uniform packaging. The questions raised about the MPC are equally pertinent to the numerous specialty casks that must be designed to meet the needs of the other waste forms the DEIS proposes to dispose of in Yucca Mountain. Questions about the characteristics, designs and certification for the other waste forms are the same as for the MPC. The DEIS is mute on the significant problems of handling different waste forms and potentially different waste packages at Yucca Mountain and the intermodal facilities where the waste will be handled.

264 *Fabrication Issues*

In a film of cask tests made in 1977, a cask is shown engulfed in flame as part of the 30-minute fire test required for cask certification. Twenty minutes after the camera was turned off, having recorded an ostensibly successful test, the cask broke open due to a manufacturing defect. An under appreciated aspect of transporting SNF is the high level of technical sophistication required to fabricate a waste cask. The challenge of fabricating casks on the massive scale required by the programs proposed by the DEIS is problematic at best and could be greatly complicated by short production schedules, sporadic program financing, and other considerations not mentioned in the DEIS.

The transportation cask is assumed to be the primary component ensuring the safety transportation of spent nuclear fuel. The slightest flaw in manufacturing casks could have a greater impact on safety than many other variables. Although it is not a traditional NEPA consideration, it is an important part of ensuring the safe transportation of waste and a discussion of cask fabrication issues should have been included.

265 *Service and Maintenance Support*

This refers to the "personnel, facilities, equipment, materials, and system for transportation cask system equipment maintenance, inspection, repair inventory, regulatory compliance, and decommissioning." Will the waste packages be opened and the waste inspected before it is disposed? Will the waste be shipped in a single container with multiple uses, or will waste be transferred from a shipping container to a disposal container? If so, where will the facility to perform such an operation be located? When will it be built? By whom?

266 *Management Structure*

The transportation privatization concept proposed in 1996 provides little more than an outline of how the contracts to transport the SNF will be awarded. The impact of the management structure on transportation safety is significant. Many of the causes of significant low-probability, high consequence accidents can be laid at the door of management practices and organizational problems. The likely cause of some of the most severe accidents to occur in recent times has been organizational dysfunction. The DEIS should have discussed how the management structure proposed to transport the waste would engender high reliability and safety.

267 *Field Operations Segment*

This segment includes personnel, facilities, equipment, materials, and systems that provide support to utilities or high level waste producers regarding receipt, handling, loading, and shipping preparations for the transportation cask systems. These field operations may be implemented by the RSC's as part of the DOE's privatization effort. However, the DEIS must describe how these services will be provided.

268 *Maintenance Facilities and Support Operations*

Hazardous materials transporters currently have elaborate, effective agreements for managing maintenance and support operations. These agreements have served the HAZMAT industry well for many years, however, it is not clear that the same institutional architecture will be adequate to service the specialized equipment used to transport SNF. The DEIS should provide a clear description of arrangements that will be made to provide en route maintenance and support.

269 *Incident Response*

An essential concern for local governments is the speed and ability to respond to incidents. The DOE's requirement to reduce and mitigate the impact of a radioactive waste spill is an important part of the DOE's program. The DEIS should have discussed how the transportation system will be organized to enhance public safety respond to accidents. The DEIS should at least provide some information about the minimum incident response performance standards required of the RSCs.

270 *In-Transit Storage*

It is inevitable that delivery schedules will be delayed or interrupted. The impacts of moving waste uninterrupted from the origin to the destination for a single shipping campaign are different from a complex, multi-state shipping campaign that will take place over a period of years. The DEIS transportation plan should have addressed the likely effects of in-transit storage on the risks of transporting waste. Storage in-transit is a likely event and the DEIS should describe the DOE's plans to manage that requirement and describe the amount of waste that may have to be stored in transit to the Yucca Mountain facility.

271 *Security/Escort*

The State of Nevada has successfully argued that the Nuclear Regulatory Commission (NRC) should reconsider the security requirements for handling SNF. The DEIS presents no information on the contribution security arrangements will make on the transportation of SNF. This is unfortunate because many responsible trucking companies have developed sophisticated systems for handling sensitive materials that would assist public understanding of the safety systems that can confound potential attackers. The DEIS should have included a description of the contribution to risk made by security and escort programs for each of the modal and implementing alternative options.

Planning and Control Segment

This portion of the transportation system refers to the "personnel, facilities, equipment, materials, and systems for general management and support normally associated with most organizations plus some that are unique to transporting spent fuel or high-level waste." This broad category provides a catchall for comments about important areas not addressed elsewhere.

272 ***Waste Form and Waste Acceptance***

There is no discussion of waste acceptance procedures and waste form and acceptance at the generator site. In previous discussions, the DOE made waste acceptance one of its critical system components, yet the DEIS does not address either the risks of generator-site waste handling or the procedures necessary to transfer waste from the DOE or generator to the waste carrier. Experience with DOE has made decontamination and decommissioning contractors wary of the DOE. It is likely that companies contracted to handle and manage the waste at the generator sites will be reluctant to do so without specific guarantees and careful compliance standards. Important questions are not addressed: Who is responsible for ensuring the waste is in the proper form? How will the waste be transferred to the RSC carrier for shipping? What are the handling procedures? Will there be similar handling procedures at each intermodal site? Are handling procedures going to be standardized? When? There are numerous important concerns with waste handling, none of them are addressed by the DEIS. The DEIS must address the issue of waste acceptance and waste form both at the generating site and at the acceptance site.

273 ***Extraregulatory Measures***

The Waste Isolation Pilot Plant (WIPP) program adopted many extraregulatory measures to reach agreement with the states along routes to the WIPP repository. These measures have been widely recognized as an essential element in the current success of the WIPP program. Will DOE agree to similar measures for the Yucca Mountain Program? If so, what are these measures? Are the WIPP measures a reliable guide to the DOE's transportation plans? Will steps to avoid tribal lands be taken? What institutional arrangements will be made to document and enforce these institutional actions? The DEIS should specify the institutional activities that will address significant stakeholder transportation concerns.

274 ***Infrastructure Improvements***

The DEIS does not assign specific roles and responsibilities for significant actions. -For example, what agency will construct road improvements and facilities, what agency will maintain them, when will these be constructed, when will the NEPA analysis be done. The sparse information contained in the DEIS makes it impossible to negotiate mitigation or even understand the proposed action. The DEIS must specify when construction on infrastructure improvement will begin, what agency will construct and maintain them, and provide a schedule for the required NEPA documentation for the projects.

275... ***Intermodal Handling Risks***

One of the challenges for risk analysts is to completely describe the risks of the activity being analyzed. In this case, the DEIS fails to adequately address the risks of transferring a waste cask from a rail car to a heavy haul transporter. One of the problems with intermodal transportation is that it increases the number of times the waste package is handled. In past campaigns, most accidents occur due to handling. The DEIS should have examined the safety of intermodal handling based on some proposed handling process. No handling process is described in the DEIS.

275 cont. Both of the intermodal handling facilities proposed in the DEIS are located in urban Clark County. In the case of the Apex facility, the facility is located near a veterans hospital, the jet fuel storage tanks for an air force base, and burgeoning residential areas. The other proposed intermodal facility, in southern western Clark County, is adjacent to two major hotels. Most of those hotel rooms would look out onto the intermodal-handling yard. All of the approximately 24,000 vehicles that use Interstate 15 to travel to or through Las Vegas would pass over the Union Pacific rail line that would carry the spent fuel to the intermodal facility. In order for the DEIS to be sufficient a Risk Management Plan required for SARA Title III facilities should be prepared as part of the final EIS.

276 ***Traffic Risks***

The DEIS proposes to use heavy haul transportation to ship spent fuel through Clark County on the northern and western beltways. The DEIS fails to examine the likelihood of an accident between the slow, cumbersome, heavy haul transporters and local traffic traveling at 70 mph. Current estimates show that approximately 70,000 cars will use the northern beltway on a daily basis. How will this traffic interact with a 300-foot long convoy of spent fuel? Since the proposed action will require approximately four heavy haul transporters to traverse the valley each day (two going to and two coming from Yucca Mountain) the traffic impact is likely to be substantial. The DEIS should have provided a traffic analysis using standard highway engineering practices to examine the impact of heavy haul transportation.

277 ***The Full Costs of Heavy Haul Transportation***

The DEIS presents misleading cost data for heavy haul transportation. The engineering analysis presented to support the cost data ignores the costs of obtaining right-of-way to build an additional travel lane on each side of the northern and western beltways. This is a particularly serious problem due to the nature of the land uses adjacent to the beltways. It is likely that acquiring right of way for additional travel lanes through expensive residential, industrial and high-density commercial land uses will be extraordinarily high. The DOE has presented a fundamentally misleading estimate of the costs of the proposed heavy haul program by failing to include the right of way costs necessary to implement the program.

The last time similar heavy haul transporters traversed the State of Nevada was in 1993 when two autoclaves were moved to a mining site. The transporters themselves moved more slowly than anticipated and caused severe damage to many bridges and culverts en route. The DEIS should consider these effects and account for the likely costs of improving Clark County's infrastructure.

278 In order for the intermodal handling and heavy haul sections of the DEIS to be regarded as complete analyses, it is necessary for the following additional reports or supplements to the DEIS: An analysis of the risks at each proposed intermodal facility. This plan should be prepared in accordance with the Risk Management Plans mandated by the Clean Air Act Amendments of 1996. A revised DEIS that provides a specific analysis of the risks of intermodal handling at each of the proposed facilities should be prepared. The handling procedures at each facility must be described.

279 An analysis of the risks and impacts of the heavy haul transportation routes through urban Clark County. This analysis should examine the traffic impact of the transportation as well as the risks of this unprecedented program. The engineering data should be modified to include the costs to acquire right of way for the additional travel lanes. The report should also include an estimate of the costs to improve existing infrastructure to accommodate the transportation program.

280... The heavy haul alternative is inadequately described. There is no consideration given for the operational requirements of a heavy haul shipping campaign as described by the DEIS. The vehicles proposed for use by the DEIS typically operate at speeds between 10-25 mph. They can

280 cont. only operate during daylight hours. Therefore , it is unlikely that even in the most optimistic scenario, heavy haul trucks can successfully travel from either intermodal site in other than perfect conditions. The possible need for overnight stopping areas, where those areas would be located and how they would be secured are not described by the DEIS.

281 *Nevada Route Selection*

The DEIS is insufficient because it fails to unambiguously select a route ("implementing alternative" is the phrase used by the DEIS) through Nevada. The DEIS attributes this glaring omission to the lack of precise information about the transportation system. Clark County agrees with DOE's assessment. However, it is the job of an EIS to define and assess the transportation system. The DEIS has numerous shortcomings, but several areas in particular stand out. First, the DEIS does not examine fundamental traffic conditions along any of the routes. Important data such as traffic volumes, capacity, travel time, congestion, road geometry, grades, the inconvenience to motorists caused by construction delays, increased insurance costs due to construction accidents, increases in accidents, lane widths, the traffic effect of a 300 foot long convoy traveling through dense traffic four times daily is not described, the health effects of rail transportation are understated because the rail configuration in Southern Nevada requires the waste to travel through Las Vegas twice, once going south and once going north to the classification yard in Sloan, and other traffic data are completely omitted. Such data should have been part of the EIS. The DEIS studied routes through Nevada from a very narrow engineering and radiological health perspective.

The DEIS indicates that a number of additional studies will be required prior to making a final decision about an implementing alternative. These studies include transportation corridor EIS', socio-cultural analyses, and engineering analyses of implementing alternatives. Yet, the DEIS does not indicate when these studies will be performed and what agency is responsible for performing the studies. Based on the DEIS, it is impossible to know when and even how many implementing alternatives will be chosen.

In a 1995 document cited as a reference by the DEIS, the DOE indicated that that the decision to select an implementing alternative through Nevada would be made in consultation with the affected counties and would be described in the EIS. Nowhere in the DEIS does the DOE mention how an implementing alternative will be chosen or when the affected counties will be consulted.

The problem of selecting a route through Nevada to the Yucca Mountain Repository is a challenging one that should have been addressed by the DEIS. The DEIS identifies a number of "implementing alternatives" that can be used to ship waste through Nevada. However, the DEIS does not select a single route. The DEIS not indicate how such a route will be selected. There are a number of troubling aspects of the Nevada routes identified in the DEIS.

The Special Status of the Air Force

282 Despite uncertainties about the selection of an implementing alternative through Nevada, the DEIS designates the Chalk-Mountain route as a "non-preferred" route. The Chalk Mountain Route is opposed by the US Air Force. The DOE has granted the Air Force special status by allowing the Air Force to designate a non-preferred route. The DEIS must explain why this decision was made, what criteria were used and applied. The DOE should also explain why this process of selection was closed to the public and oversight agencies.

283... *Analysis of State Routes*

In 1986, the State of Nevada began a process to analyze and identify potential SNF the routes through the state. These are depicted in Figures 3 and 4 below:

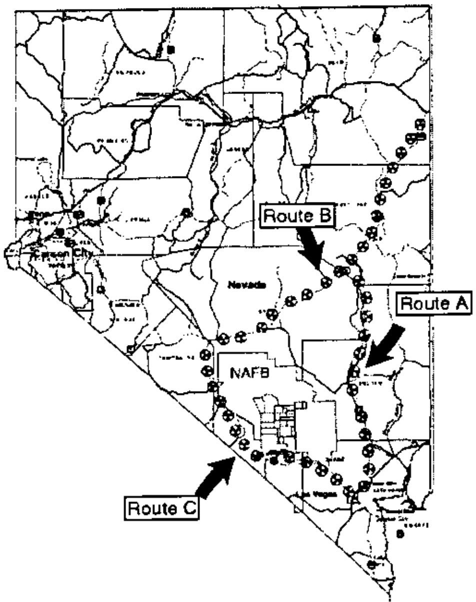

Figure 3 State of Nevada identified Routes A, B, and C

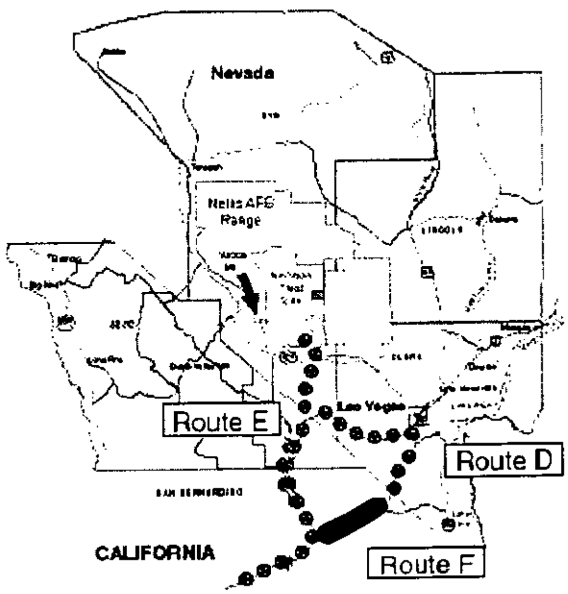

Figure 4 State of Nevada identified Routes D, E, and F

283 cont. Clark County agrees with some of the findings in the State report. However, Clark County's economic growth in the past decade has rendered some of the State of Nevada routes outdated. The recently approved Enterprise Land use plan charts a course for rapid and extensive economic growth in the southwestern part of urban Clark County. Due to this expansion, the State of Nevada routes C through F now pass through urban Clark County and should be regarded as non-

283 cont. preferred routes by Clark County. Among the routes considered by the State of Nevada, only the B route is acceptable to Clark County.

284 The DEIS should be rescinded and a new DEIS issued that 1) assesses traditional transportation impact concerns, 2) State of Nevada identified routes, 3) bypass routes (should the northern beltway become unavailable), 4)describe why the Air force was awarded special status and Clark County was not, and 5)describe the process used to select one or more implementing alternatives.

285 ***National Route Selection***

The DEIS is incomplete due to its failure to analyze the impact of transporting SNF across the nation. Of 146 pages in the transportation section of the report, only 17 pages are devoted to national transportation of Spent Nuclear Fuel. The problem of selecting routes on which to transport radioactive materials has incited litigation and defied every attempt at reaching consensus. The problems associated with route selection begin with construction at Yucca Mountain and flow back to each of the generating sites. Each suite of routes poses different risk characteristics nationally as well as in the State of Nevada. The DEIS assumes that truck and rail shipments on different routes possess the same risk characteristics. The DEIS presents the shortest distances to transport the waste without considering any of the likely alternatives to shortest distance.

286 Other routing arrangements may be necessary to accommodate weather differences, political changes or infrastructure changes. The DEIS should have examined the default routing scenario as the "no action alternative" and then presented several other routing suites for comparison. One proposal made by the State of Nevada Nuclear Waste Project Office (NWPO) was a "consolidated southern strategy" that would ship waste primarily through the southern portion of the nation. The use of alternative routing strategies produces alternative risks. The DEIS should have addressed this.

287 The DEIS assumes that selection of a route through Nevada has no influence on the transportation risk. The cities through which SNF will be transported depends upon the routes selected. The routes selected depend, in large part, upon the routes selected through Nevada. The DEIS does not provide a description of the routes by which the waste would be transported across the country. The DEIS does not describe the effects of transporting waste through the following corridor communities:

- Atlanta
- Chicago
- Dallas
- Denver
- Los Angeles
- Nashville
- Omaha
- Salt Lake City

288 By presenting a single set of distances, the DEIS assumes that the choice of a route in Nevada has no effect on the risk. This is not the case. For example, shipping waste from the Brunswick nuclear reactor to the DEIS' proposed Jean intermodal site by the shortest route produces a different route than shipping to the Valley Modified intermodal site-even though the two intermodal sites are only thirty miles apart.

Selecting a route through to the Jean/Sloan intermodal transfer location has different risk characteristics than shipping the waste to the Valley Modified Intermodal site. The risk should be described in a way that permits comparison of routes. The DEIS assumes a single route-there is no comparison-e.g. for the base case and a consolidated southern strategy.

289 In 1995, the DOE reported that route evaluation criteria for the various transportation routes would be described in the DEIS. Nowhere does the document provide any description of how and why the DEIS will select the route evaluation criteria, how and when they will be applied and when the final route decision will be made.

290 The international trend in hazardous materials transportation is to consolidate shipments and standardize packaging-neither of these is part of the DOE's plan. The DEIS should bound its risk analysis with consolidated and unconsolidated shipments. In this analysis, waste shipments would be gathered regionally and then shipped in such a way as to clean out one region at a time. For example, waste from reactors in Northeastern states would be simultaneously shipped to a single terminal point and then conveyed to the repository. Such an analysis would bound the diffuse DOE program with the more focused national and international practice. Implications for risk would be highlighted by such an approach.

291 The routes described by the DEIS address shipments only from eastern reactors and ignores the shipments from reactors to the west and south of the Yucca Mountain location. Shipments from southern and western reactors will necessarily follow a different route than the waste from eastern reactors. The DEIS should make clear that those routes have been studied by the DEIS and that the risk assessment provided considers them. The DEIS does not specifically describe the routes from any generator site and should be revised to reflect the routes proposed by the DOE. The DEIS must provide clearly marked maps that show the routes used to transport spent fuel from each shipping site to the final storage site. The DEIS must provide an analysis of national routing impacts at a level of detail sufficiently precise to understand the risk of transporting these materials across the nation.

Modal Alternatives

292 The DEIS fails to analyze some of the numerous alternative modes as well as their significance.
The DEIS argues that the DOE has established the appropriate boundaries within which waste
will be shipped by examining the maximum truck and the maximum rail scenarios. The DEIS
does not provide a credible analysis of the likely modal choices faced by the transportation
293 program. Specifically, the effect of barge transportation is not mentioned. The selection of
modes involves significant trade-offs as is indicated by the DEIS. While the latent cancer
fatalities (LCFs) associated with incident-free truck travel are greater than for rail, the accident
consequences for rail transportation are greater. Mode choice affects the cities through which
waste is transported, the time of year in which the waste is transported, the kinds of populations
(urban versus rural) exposed, and many other critical health and safety issues. The DEIS should
have included a thoughtful and careful analysis of the implications of the alternatives presented as
bounding scenarios. This should have been provided for Nevada as well as for the United States
as a whole. Mode choice for the shipment of SNF is a critical risk variable with system-wide
implications on the cost and safety of the actions proposed in the DEIS.

593 Another aspect of mode selection addresses the cost-effectiveness of the program. Truck
transportation tends to be twice as expensive as rail transportation. The mode selected to move
the waste will have a great bearing on the ultimate price of the program. Yet, the DEIS is silent
on this point. Rather than address the issue, the DEIS presents only the costs to construct and
maintain the various implementing alternatives. Unfortunately, these figures can be misleading.
The DEIS should present the shipping cost for each of the implementing alternatives as well as
the shipping cost. In order for the DEIS to be complete, the DOE must examine the problem of
294 modal choices in detail. The DEIS should, at least examine a shipping scenario in which barge
transportation is maximized.

Risk and Decision Making

295 A careful review of the DEIS leaves the reader unclear as to what the report is about and why the report recommends the Proposed Action. If the decision to ship waste to Yucca Mountain is made, that decision cannot be supported on the basis of the human health risks presented in the DEIS. Based on the DEIS, the risk to human health when transporting the waste far exceeds the risk of leaving the waste in place.

This aspect of the report highlights the uncertain role risk assessment plays in the decision making process. In a 1995 report, a DOE contractor described a process for choosing a route through Nevada to Yucca Mountain. Nowhere in that report did the contractor mention human health risk as a criterion. Part of the uncertainty about the role of probabilistic risk assessment in the decision-making process is due to the inconsistent way in which PRA is performed. The differences between the DEIS produced by the DOE and the Generic EIS (GEIS) produced by the Nuclear Regulatory Commission for the relicensing of nuclear power plants are inconsistent. The differences in methodologies used to prepare transportation risk analysis are substantial and effect the results of the analysis.

Inaccessibility

296 The DEIS presents its analysis in a way that is not accessible by the public. The DEIS spares the reader the inconvenience of interpreting the results of its analysis by not including the outputs of the HIGHWAY, INTERLINE, RADTRAN, and CALVIN models that were the basis of the transportation risk assessment. In so doing, however, the DEIS gives the impression that something was hidden. Clark County received the transportation information supporting the DEIS mid-way through the comment period and has not been able to verify the findings of the risk assessment. The HIGHWAY and RADTRAN 4 printouts appended to the GEIS are so cryptic as to be useless to anyone who is not familiar with both HIGHWAY, RADTRAN, INTERLINE, and the assumptions used to calculate the risk. An expert in RADTRAN analysis would have difficulty extracting sufficient information from the documents provided. Additionally, it is impossible to determine from Attachment 2 whether the spent fuel isotope inventory input represents the fuel considered in the GEIS. The report does not contain enough information to enable a reviewer to verify the analysis contained in the report.

No Assessment of Economic Consequences

297 Nowhere do the DEIS and GEIS reveal the details of radioactive materials cleanup costs resulting from the "Maximum Reasonably Foreseeable Accident." The DEIS relies on the RADTRAN 4.019 computer program to calculate the risks of transporting waste. A standard output of this program is an estimate of the cost to decontaminate urban, rural, and suburban land uses in the even to of an accident. These outputs should have been provided in the report. When originally released, the DOE's 1986 Environmental Assessment for Yucca Mountain assumed a very severe accident could release 1,380 curies of Co-60, Cs-134, and CS-137. The cleanup costs for a rural area were estimated at over $600 million (in 1985 dollars) and 460 days to perform the cleanup. The DOE speculated that cleanup in an urban area would cost several billion dollars. The DEIS should have provided the same information.

Special Risk Effects Not Considered

298... The DEIS fails to consider the adverse impact spent fuel waste shipments may have on Clark County's land valuation and tourist-based economies. Despite long-standing legal precedents, the DEIS fails to consider the full context of impacts in which the transportation takes place.

298 cont. However, the number of accidents predicted by NRC could have a major adverse economic impact on the Southern Nevada even if there are no releases of radioactive materials.

299 In order for the DEIS to be a sufficient document, the practice of risk assessment used in the DEIS should conform to best practice in the field. Based on a comparison with the GEIS, it is not clear how a probabilistic risk assessment for transporting high level radioactive should be done. A primary requirement for the DOE is to recognize the unique circumstances of the planned transportation operations for which there is little or no historical experience and empirical data. The transportation of spent fuel from reactors to the proposed repository at Yucca Mountain has no parallel. Previous spent fuel transportation experience is qualitatively different from the proposed action. The DEIS should be withdrawn and replaced by new DEIS that performs a complete probabilistic risk assessment that is found to be sufficient by a qualified peer review committee.

Terrorism and Civil Disobedience

> "Let us say that there are two parties to the conflict: The first party is world Christianity, which is allied with Zionist Jewry and led by the United States, Britain, and Israel; while the second party is the Muslim world. In such a conflict, it is unacceptable to see the first party mount attacks, desecrate my lands and holy shrines, and plunder the Muslims' oil. When it is met by any resistance on the part of the Muslims, this party brands the Muslims as terrorists. This is stupidity. People's intelligence is being belittled. We believe that it is our religious duty to resist this occupation with all the power that we have and to punish it using the same means it is pursuing against us."
>
> Osama Bin Laden
>
> Interview on Qatari Radio 5/99

300 The DEIS does not provide a credible analysis of the potential consequences of effects of terrorist activity. In June of 1999, the State of Nevada petitioned the Nuclear Regulatory Commission (NRC) to perform a comprehensive assessment of the security requirements for shipping radioactive waste. This much-needed assessment could establish that there is a definite terrorist threat to shipments of Spent Nuclear Fuel (SNF) and that shipments of high-level waste through Clark County, Nevada en route to Yucca Mountain could be especially vulnerable. The threat of terrorist activity is not trivial and should be taken seriously in the DEIS. The DEIS should be considered insufficient until a credible estimate of the likelihood and consequences of terrorist activity is completed. The DEIS is insufficient because it fails to consider the threat to shipments posed by a wide array of terrorists. The threat should be considered for each of the implementing alternatives considered by the DEIS.

Sources of the Terrorist Threat

The FBI defines terrorism as: the use of force or violence against persons or property in violation of the criminal laws of the United States for purposes of intimidation, coercion or ransom. The DEIS should have considered threats to shipments that stem from foreign, domestic, and special interest groups. Terrorism has the effect of causing various injuries from loss of life and injuries to property damage and disruptions in services such as electricity, water supply, public transportation and communications. The threat to transportation systems is especially acute. The 1995 Arizona derailment, the Oklahoma City Bombing, the Atlanta bombing and the investigation of the World Trade Center bombing suggest four characteristics of terrorist groups:

1. They are willing to attack trains, bridges, and tunnels without warning-they are willing to kill, maim, and terrify tens to hundreds of people at a time;

2. The technical expertise displayed by terrorist groups in planning their attacks may be adequate to defeat security measures;

3. The sophistication of terrorist groups demonstrates their ability to at least challenge the containment performance standards of NRC-certified shipping containers; and

4. Attacks on infrastructure may be carried out with use of homemade explosives and do not require the procurement of exotic weapons to be successful.

Recent assessments of the terrorist threat address potential terrorist use of nuclear weapons and potential terrorist actions to disperse radioactive contamination using radiological weapons and reactor sabotage. The NRC responded to concerns about the terrorist threat by adopting new regulations in 1994 intended to thwart a terrorist attack on a nuclear power plant with a truck bomb. The U.S. Interagency Counter proliferation Program Review Committee (CPRC) 1997 Report to Congress summarized potential threats resulting from nuclear weapons and dispersal of radioactive materials utilizing conventional weapons. Based on an extensive review, the CPRC concluded:

> "Non-fissile radioactive materials dispersed by a conventional explosive or even released accidentally could cause damage to property and the environment, and cause social, political, and economic disruption. Examples of non-fissionable, radioactive materials seen in press reports are cesium-137, strontium-90, and cobalt-60. These cannot be used in nuclear weapons but could be used to contaminate water supplies, business centers, government facilities, or transportation networks. Although it is unlikely they would cause significant numbers of casualties, they could cause physical disruption, interruption of economic activity, and psychological trauma to the work force and general populace, and require some measure of post-incident cleanup."

Falkenrath, Newman, and Thayer concluded similarly:

> The simplest radiological weapon would consist of a conventional explosive surrounded by a quantity of any radioactive material. Crude radiological weapons are far more accessible than nuclear weapons, and are therefore more likely to be used by non-state actors. However, although a radiological weapon could contaminate an area and be costly to clean up, building and using such a weapon is not an easy way to produce mass casualties. Large quantities of highly radioactive material would generally be needed to produce strong effects over even a moderate area. Obtaining and working with large amounts of such materials would be challenging because of the high radiation levels involved. Due to widespread public fear of radiation, however, a radiological attack might trigger panic, social, and economic disruption out of proportion with its real destructiveness.

According to the CPRC report, there have been threats but no actual radiological contamination incidents by terrorist groups to date. In 1995, Chechen insurgents threatened to disperse cesium-137 in Moscow.

> "The Chechens directed a Russian news agency to a small amount of cesium-137 in a shielded container in a Moscow Park, which the Chechens claimed to have placed there. Government spokesmen told the press that the material was not a threat, and would have to have been dispersed by explosives to be dangerous. According to Department of Defense assessments, there was only a very small quantity of cesium-137 in the container. If it had been dispersed with a bomb, an area of the park could have been contaminated with low levels of radiation. This could have caused disruption to the

populace, but would have posed a minimal health hazard for anyone outside the immediate blast area."

The CPRC also noted that the Japanese "Aum Shinrikyo" cult, which twice manufactured and used sarin nerve gas in Japanese subways, also tried to mine uranium in Australia and to purchase Russian nuclear warheads. On March 2, 1999, Secretary of Energy Bill Richardson began his speech to the National Press Club by disclosing a previously unreported threat:

> "The FBI receives word of a telephone threat that radioactive material is aboard an AMTRAK train in Montana and that its passengers are in danger. Within hours, specialists including the Department of Energy's Nuclear Emergency Search Team arrive. Both the eastbound and westbound trains are diverted to a lonely stretch of track and searched for a potential killer. This is not a plot twist in a Tom Clancy thriller nor a figment of a Hollywood screenwriter's imagination. This incident occurred February 20th, aboard the Empire Builder in central Montana. No radioactive material was found. No one was injured. This time."

301 To date, two threats against spent fuel shipments have been reported in the United States since 1984. In November 1984, Northern States Power (NSP) shipped spent fuel from the Monticello reactor in northern Minnesota to a storage facility at Morris, Illinois. On February 4, 1985, NSP received a telephone threat warning that a group of anti-nuclear protesters would use a small airplane to stop a train carrying spent fuel from Monticello to Morris. On October 27, 1986, an unknown party removed a 39-foot long section of rail along the Burlington Northern route used for these shipments in Golden Valley, Minnesota. Authorities found a sign reading "Stop Rad-Waste Shipments" near the tracks. This incident did not result in damage to the train transporting spent fuel. However, a Burlington Northern train hauling lumber, scheduled immediately prior to a train transporting spent fuel from Monticello, derailed at the site of the sabotage.

Clark County believes that the threat of a terrorist attack on a spent fuel shipment capable of causing radiological sabotage should be considered credible and should be evaluated in the DEIS. History clearly suggests that although the terrorist threat may be low, it is not so low that it can be ignored.

The FBI found that the major determinants of the character of a terrorist attack are: 1) the technological means, 2) the political motivation behind the attack, and 3) the weaknesses of the target. The FBI believes that changes will occur in the motivations and goals of terrorist groups. Traditional motivations for terrorism (ethnic, tribal, and religious animosities) will continue and intensify. The disintegration of the Soviet Union and Yugoslavia have fostered entirely new groups that are both well-equipped and well-schooled in terrorist activity. As the World Trade Center bombing demonstrates, terrorists activities span the globe.

Clark County's Attractiveness as a Terrorist Target

302... Clark County presents terrorists with an attractive target for a number of reasons. Each of these reasons, taken individually provides a sound rationale for concern about a terrorist threat. When viewed together, they present a compelling argument in favor of anticipating a terrorist event of some sort. These reasons, visitors, operational consideration, infrastructure, military facilities, and symbolic value are discussed below.

Visitors

"Major events taking place inside the United States may be seen as attractive targets for terrorism."

Terrorism in the United States 1996

Federal Bureau of Investigation

302 cont. Clark County's population is an attractive target for terrorists. The sheer number of visitors to Clark County (31 million visitors in 1998) provides terrorists with an attractive target. The concentration of people created by Clark County's mega resorts make it possible for terrorists to craft an attack that would contaminate a large number of people. An example of this concentration is easily exemplified by the intersection of Tropicana and Las Vegas Boulevard's. On the corners of this intersection, are 16,500 hotels rooms-more than are in the entire City of San Francisco. Clark County's hotels are usually 91% occupied. This inflames the problems faced by emergency services should an evacuation be necessary. A terrorist attack on a spent fuel shipment in the valley could create an accident that would overwhelm the ability of local emergency management agencies to provide protection and evacuation.

Exacerbating the problems faced by the County is the large number of special events of all types and sizes. Perhaps the largest of these is COMDEX, the world's largest computer exposition. Special events can draw up to 250,000 people to the city from all over the world. It is likely that terrorists would schedule an attack to coincide with a well-known event in order to amplify the effects of their attack through media exposure. This occurred at the Munich Olympic Games, the Atlanta Olympic Games and several others. As the FBI report notes, terrorists select targets with care and sophistication. Terrorist activities have a ready-made target in Clark County. The DEIS should present a worst-case terrorism scenario that coincides with an important local event.

Symbolic Value

The number of tourists present in Clark County has value from a terrorists' perspective not only because of the increased number of potential victims. Terrorist select targets based on their symbolic and political value. One prominent author paraphrases Clausewitz by characterizing terrorism as "politics by other means." Targets with symbolic significance like government buildings and special events are particularly attractive. This was demonstrated by the Oklahoma City bombing, the Munich Olympic Games, and the Atlanta Olympic Games. Terrorists wish to get immediate publicity for their cause. Any attack in Las Vegas, the world's center for tourism, would receive extensive media coverage. This problem will increase in the future as Las Vegas adds new events, such as race tracks, major sports teams and so on.

Other aspects of the region deserve mention in any discussion of the symbolic value of examining terrorist activity. The first aspect is the nature of the Nevada Test Site (NTS), which partly contains Yucca Mountain. The DOE conducted approximately 1,000 nuclear tests at the site from the 1950's to the late 1980's. These tests became extremely controversial and incited protest marches and acts of civil disobedience. Even without nuclear testing, the NTS remains a lightning rod for opponents of nuclear power as well as nuclear energy. It provides antinuclear groups with a powerful raison d'être and ensures the likelihood of an ecoterrorist attack on shipments through the regional remains a real possibility.

The second aspect of Clark County's symbolic value is due to the controversial nature of its economy. The symbolism of killing Americans in their most famous tourist community makes Clark County a much more attractive target. The Las Vegas Convention and Visitors Authority (LVCA) has surveyed peasants in India and found that they were aware of two cities in the US-New York and Las Vegas. Las Vegas may be regarded as anathema by fundamentalist regimes in the Muslim world because it represents everything that is corrupt and sinful about the West. Clark County's symbolism is an important characteristic that should be examined by the DEIS.

Military Facilities

302 cont. Nellis Air Force Base, its auxiliary facilities, and the Nevada National Guard armored cavalry squadron (1st Squadron/221st Cavalry) provide options for a terrorist group to distract local law enforcement, or to divert weapons useful in an attack on a shipment.

The close proximity of these facilities to several of the implementing alternatives for transporting the waste increases the likelihood that a terrorist group would favorably view this area for a coordinated series of terrorist events. These facilities also assist in the response to and the mitigation of a terrorist attack. The benefits of these facilities should be assessed. In that assessment should be some analysis of how well they have been integrated into local emergency response planning.

Methods and Operational Considerations

The DEIS' treatment of terrorism relies on incomplete analysis of the ways in which terrorists are likely to attack. Both the methods and the operational characteristics of a terrorist attack should be examined.

Methods

The weapon used by terrorists to attack a shipment of nuclear waste is an important issue that the NRC has agreed to reconsider. The NRC has rightly concluded that it must reexamine the threat defined in its 1984 rulemaking. The DEIS accepted the Sandia National Laboratory's 1984 and 1999 reports that evaluated the damage to a canister using a military M3A1 demolition charge. The State of Nevada has argued that more sophisticated anti-tank weapons should be considered potential threats. Clark County agrees with this and recommends the NRC examine a terrorist scenario in which the terrorists are equipped with a TOW II or Milan antitank missile or a car bomb as their primary weapon. As the FBI's 1996 report stated:

> "The threat at the lower end of the spectrum is likely to grow as well. The M-16, M-10, Uzi and AK-47 assault rifles will be supplemented by standoff weapons like Stinger anti-aircraft missiles, LAWs and RPG-7s, already available on the world weapons market. Just because a weapon is relatively unsophisticated does not mean it cannot cause massive casualties. A stinger missile aimed at a jumbo jet as it takes off or as it approaches a large metropolitan airport could cause tremendous casualties. A LAW or RPG round lobbed into the right area of a nuclear power plant could produce catastrophic consequences."

These standoff weapons provide the opportunity for highly flexible hit and run attacks. Either of these types of weapons would be more realistic than the cratering charge in the current scenario. A review of terrorist activities reveals that the antitank missile and car bomb are favorite weapons of terrorists and are likely to impose greater strains on the canisters than the M3A1 cratering charge currently being considered.

Civil Disobedience

303... As a subset of terrorism, the problem of Civil disobedience is another area in which the DEIS should have made some statement. The transportation of spent nuclear fuel to the Gorleben facility in Germany has touched off numerous annual riots. These riots have resulted in the destruction of infrastructure and deliberate efforts to prevent the transportation of waste. The Nevada experience with civil disobedience is long and centered on opposition to the Nevada Test Site. To date, the protestors have refrained from acts of violence; however, the decision to store HLW in Yucca Mountain could be viewed by some radical groups as illegitimate. It is possible

303 cont. that an ecoterrorist group could, while "monkeywrenching" the transportation of spent fuel, inadvertently cause a more severe accident to occur. Certainly, the DEIS must consider the possibility of civil disobedience as an impact.

304 In order for the DEIS to be regarded as a credible document, it is important that certain modifications be made that will ensure the DEIS has properly addressed the problem of terrorist attacks on HLW casks. These are:

- The DEIS should contain a safety assessment that discusses the relative security of shipping waste via dedicated trains and general freight. The safety assessment should also compare the safety of transporting the waste via dedicated train and truck.
- The DEIS should examine the implications of advance approval of truck and rail routes. Security considerations should be incorporated into rail and truck routes selection and RADTRAN modeling should be performed for alternative security scenarios to assess the relative benefits of security considerations.
- The DEIS should examine the safety implications escort requirements to include more than a single driver as a possible escort.
- The DEIS should discuss the types and character of the terrorist threat likely to effect the proposed action. Civil disobedience should also be included in that discussion.
- The DEIS should report on the vulnerability and utility of local military facilities to likely terrorists.
- The DEIS should relate the security of waste shipments to the demonstrated and published techniques used by terrorists.
- The DEIS should report the results of a full-scale test of the effects of a TOW II missile impacting obliquely on a GA-4 cask from a range of 1,000 meters.

Human Factors and Organizational Factors in the Draft Environmental Impact Statement

305 The DEIS is insufficient because it fails to consider the contribution of human and organizational influences on the risk of transporting high level waste through Clark County, Nevada. These influences will be referred to as human factors and organizational factors respectively. Clark County's comments will highlight how both human and organizational factors contribute to risk. The DEIS does not address these factors and therefore understates the likelihood of an accident and the human health risk.

The reasons the DEIS ignores these factors are found on page J-52 of the appendix. Here the DEIS states that Federal requirements for design, manufacturing, and handling of the waste will preclude any significant human error. Clark County believes this position is incorrect for two reasons.

First, the DEIS assumes that Federal guidelines will be followed throughout the entire period of the proposed action without fail and that the complex human-machine system required to implement the proposed action will work with uniform safety through the duration of the proposed action. The DOE's position on this issue is surprising since the DOE's recent experience with leaking waste containers. Additionally, a 1979 test of nuclear waste containers caused a cask to break open after a short time due to a manufacturing flaw. Despite these significant incidents, the DEIS has not treated human factors with appropriate diligence. The second shortcoming of the DEIS is that in ignoring human factors, the DEIS also employs a narrow definition which ignores the considerable problem of organizational factors. Again, this is a surprising omission because of the number and severity of accidents in which these factors play a prominent role.

306 By completely relying on the design of the cask, the DOE discounts the significance of the other components of the transportation system. Clark County's comments will present a typology of these organizational errors and apply them to the problem of transporting nuclear waste. Clark County's comments will also provide several examples that highlight how urgently the DOE must address the problem of organizational factors in its EIS. The methodology used in the DEIS to calculate the human health risks to the public can be substantially improved by assessing the effects of human and organizational factors on the frequency and severity of failure scenarios. The focus of human factors analysis is on the interaction between human beings and the system of equipment, facilities, procedures and environments used in the high-level waste disposal system.

Human factors are not a trivial adjunct to a risk assessment; rather it is a crucial component of an analysis. Shinar presented data that indicated that human behavior was the dominant cause of accidents-over 90 percent. The Department of Transportation's Bureau of Transportation Statistics estimates that approximately 75% of truck accidents are the direct result of human behavior. The problem of human factors is real and vital to any attempt to understand the problems of transporting SNF through Clark County.

What are human factors?

307... For the purpose of this review "human factors discovers and applies information about human behavior, abilities, limitations, and other characteristics to the design of tools, machines, systems, tasks, jobs and environments for productive, safe, comfortable and effective human use." From this definition it is clear that the DEIS has failed to provide any substantive analysis to support the conclusions drawn in the body of the report. There are no design specifications, system description, or indeed any specific information about how the transportation system will operate and how it will function in a way that will minimize accidents.

In the absence of any serious treatment of the subject, Clark County will suggest key areas in which a human factors can be addressed in a supplemental analysis that must be performed in order for the DEIS to be regarded as a serious document. These suggested factors should be considered a floor rather than a ceiling. These minimum standards should be seen as the minimum basis on which to build a complete and persuasive analysis of the challenges presented by human factors.

Human Factors Baseline

These comments define broad areas where the DOE should prepare an extensive study of the likely effects of human factors on the nuclear waste transportation system. This analysis should be performed for both rail and truck shipments. Four categories should be examined: operator behavior, perceptual judgment, and risk taking.

Operator Behavior

Operating a truck or railroad engine requires the full range of human capabilities. Operators must be aware of their environment, make decisions, and use their motor skills simultaneously to be able to operate a train or truck safely. Research has identified behaviors that contribute to accidents such as inattention, incorrect judgment and risk taking. Each of these factors contributes to risk in some way. Operator behavior has an important influence on the likelihood and severity of accidents. The chart below depicts the sources of operator behavior on accidents from an analysis by Malaterre:

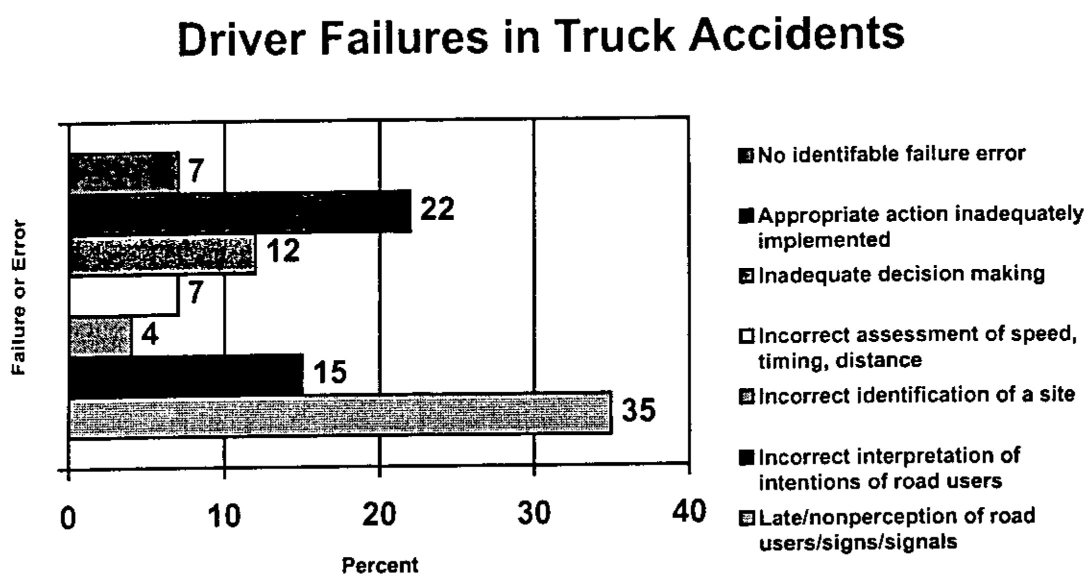

Figure 5 Driver Failures in Truck Accidents

307 cont. These statistics suggest that the DEIS could be considerably improved through the inclusion of human factors analysis in the report.

Perceptual Judgments

Operators of trucks and railroad engines rely almost exclusively on visual perception of the environment for information. Visual perceptions provide vehicle operators with the basis for making decisions about driving behavior. One of the activities drivers use to collect visual data is the visual scan of the road. Research shows that drivers scan roadways differently based on their driving experience, fatigue, familiarity with the roadway, and several other variables. The effects of this aspect of driver behavior on risk should be studied and included in the Final EIS.

Another perceptual judgment, which effects the driving task, is speed. Drivers typically use the speedometer to gauge the speed of their vehicle. When other tasks intrude, however, drivers tend to estimate speed without aid of speedometer. A phenomenon that is of interest in this case is that of "adaptation." "In driving adaptation is tendency to perceive a given speed to be less when a person has previously adapted to a higher speed and to be higher when a person has previously adapted to a lower speed." Thus, drivers exiting a superhighway tend to drive at a higher speed than they think they are driving. This is an especially important consideration for Clark County.

The DEIS proposes using county-owned roads on which to transport the waste. The DEIS proposes using the northern and western beltway on which to transport the waste. The waste transported on this route may be on 200-foot long tractor-trailer combinations (heavy-haul) that would travel at considerably slower speeds than the prevailing traffic speed of 65 miles per hour. The high level waste shipments would also share the beltway with commercial truck traffic and regular passenger traffic. Trucks and cars exiting Interstate 15 at high speeds pose an increased likelihood of a rear end collision with a nuclear waste shipment due to the adaptation phenomenon. Sanders concludes: " Many rear-end collisions involving slow moving or stopped vehicles on the highway are probably caused by inaccurate perceptions of closure rates." An increased likelihood of collisions should be examined due to the proposed use of Clark County's beltway and the "adaptation" phenomenon. There are other perceptual judgments that should be

307 cont. addressed by the DEIS in a complete analysis of the human factors effects on the safety of transporting high-level waste.

Risk Taking

The technical literature does not support many definite conclusions about how a driver's willingness to take risk affects safety. However, some information is clear. Behaviors that have not resulted in an accident are considered less risky. Drivers will accept riskier behavior when there is a payoff for doing it or a loss for not accepting the risk. The problem of risk taking needs careful study due to the DOE's proposed arrangements for transporting the waste. The DOE's privatization strategy could impose the kinds of economic incentives on drivers that would increase their risk-taking behavior. The for profit approach employed by DOE's program to transport the waste may result in routes that are optimized for time and distance route selection rather than route selection based on regulatory criteria. Economic considerations may also cause drivers to take risks they would not otherwise take. Once again, the problem of risk taking deserves study in the DEIS. However, in order to explore the problem, it would be necessary for the DOE to produce a comprehensive and thorough description of the system used to move waste from the generating or storage sites to Yucca Mountain. The DOE has not yet done this.

The DEIS is deeply flawed by its failure to address the human factors of transporting high-level waste. Key questions that are unanswered by the DEIS are: What is the contribution of human factors to truck and rail accident rates? How can this contribution be mitigated? Is the effect of human factors reflected in the accident rates used in the DEIS? Does the DOE's transportation system have a positive or negative effect on these factors? If so, is the effect significant? Does the design of the rail and highway infrastructure in Clark County exacerbate or mitigate these effects? Until these fundamental questions are answered the DEIS cannot be considered adequate.

Organizational Factors

"..we are beginning to admit to ourselves something that we have always known, i.e. that the main variables, the major determinants of plant safety, are not valve failure rates and such, but rather more amorphous and intangible entities that go by such names as morale, esprit de corps, management attitude and so on."

International Nuclear Safety Advisory Group (INSAG)

Quoted in Wu, J.S.

On the Inclusion of Organizational and Managerial Influences in

PSA of Nuclear Power Plants

308... One of the reasons Clark County, Nevada is so interested in the issue of transporting radioactive waste is because it has the unfortunate distinction of being an area through which the Department of Energy has transported leaking containers of radioactive waste. On December 15, 1997, a shipment of waste containers was observed to be leaking fluid during a routine visual inspection of the truck near Kingman Arizona. Although the proximate cause of the leak was a faulty box, subsequent investigation revealed series of misunderstandings, negligence and duplicity about the condition and safety of the DOE's low-level waste disposal program. Some of these problems are highlighted by quotes from the DOE's investigation of the incident:

308 cont. "The procedures detailed in Section 2.2.2 are intended to preclude free liquids in shipments to NTS. Both DOE and FDF believed them to be effective. However, free liquids have been observed to form under normal handling and shipping conditions."

"Modification 4, dated April 9, 1997, significantly changed the design of the container lid, the reinforcement around the top of the container, the vertical reinforcement in the corners, and also changed the base metal to the thinner 12 gauge. Although the Drop Test and the Compression Test were performed on the new design, none of the other tests required of the original design, including the Vibration test, were performed."

"This reorganization left only one FDF Quality Assurance person to perform Quality Assurance duties related to waste certification where previously four had been assigned."

"The DOE Waste Management team leader stated that he strives to conduct walk-throughs of all waste management areas weekly and requests the same of his team members but, due to conflicting duties, this has not always been done."

"The CGR test sample provided during proposal evaluation testing did not match the design of the White Metal Boxes that were delivered under the resulting contract, beginning in September 1995."

"The contract resulting from the June 1995 testing did not include specifications that would ensure that the design delivered would reflect the design tested."

"However, the low level of risk to the public and the environment associated with these shipments caused management attention and concern to shift to other operations with potentially greater health and safety risks."

"The procurement process was expected to provide a strong, tight container. It did not through a series of misjudgments."

These comments from the DOE's investigation of the failure to safely ship low-level waste to the Nevada Test Site each relate to the typology of organizational factors described below. Other major accidents have been caused by similar organizational problems. The Three Mile Island accident was worsened by maintenance tags concealing safety indicators, the Exxon Valdez accident occurred despite extensive automated safety devices, the Bhopal accident occurred because of differing cultural assumptions. In each case, organizational factors contributed more to the accident than would have been acknowledged by the methods used in the DEIS. The risk analysis contained in the DEIS should be supplemented by an analysis of the organizational risks created by the DOE's transportation system. That system must be described in full in order for it to be evaluable.

Organizational factors

As the comments above indicate, organizations have greater influence on risk than is recognized by the risk assessment presented in the DEIS. While human factors typically treat the behavior of a single person within a system, organizational factors examine how groups of people and the organizations they form interact within a system.

In a report for the State of Nevada, Dr. William Freudenburg proposed a typology of organizational risks that describe Clark County's concerns with respect to transporting HLW. Freudenburg's characterization of the organizational failure closely reflects Clark County's own experience with the Department of Energy's Low Level Radioactive Waste Shipments and similar shortcomings will undoubtedly occur in the high level waste program.

308 cont. *Organizational Variations in Commitment to Risk Management*

Organizations vary in their commitment to safe practices and to ensuring the safety of the public. As the quotation that opens this section of comments indicates, it is vital for organizations to engender a commitment of this type in staff at all levels. The publication of standard operations procedures and detailed manuals does not ensure compliance. It can be persuasively argued that the "real risk" of transporting waste derives primarily from the failure of organizations to follow their own procedures. The list of accidents that can be attributed to organizations that redirected their efforts to production rather than safety is long. The significance of many of these accidents (Three Mile Island, Chernobyl, Bhopal, Challenger) suggests that organizational influences should have been a central component of the DEIS analysis.

How the DOE and its regional service contractors (RSC's-the organizations that will ship the waste) will create a "safety culture" over time is of critical concern to Clark County. Although this problem is widely recognized, it is not analyzed in the DEIS. The DEIS wrongfully chooses to treat this complex and significant problem as if it did not exist. At a minimum, the DEIS should report how the DOE and its RSC's will 1) evaluate the RSC's for their safety culture 2) financially reward organizations that deeply value safety 3) sustain this attitude through the duration of the proposed action.

BureaucraticAttenuation of Information Flows

Organizations, typically large organizations have difficulty transmitting information internally. Top management is often surprised to learn that middle managers have filtered out or watered down safety warnings that have come from lower levels in the organizations. This is not necessarily due to negligence or malice on the part of the members of the organization. Communication is always imperfect and vulnerable to misunderstanding or distortion.

The leaking containers of low-level radioactive waste shipped to the Nevada Test Site dramatically highlight the attenuation of information in large organizations. This is particularly true for the DOE because they rely so heavily on contractors. This ensures that their organizations and information handling will be complex. In the case of the leaking White Metal box, the DOE investigating committee found that:

"In several instances communications weakness were observed....there was no trending or analysis of precursor events to identify the necessity of action to management."

The DEIS should explain how drivers, and operators involved in the packaging, handling and transportation will be able to report errors. The US military has long given pilots the ability to anonymously report safety deficiencies about aircraft to avoid reprisals and to promote reporting. The features of the DOE transportation system description in the DEIS must describe at a minimum how that system will 1) transmit information about transportation flow through the DOE, 2) share information between the DOE and each of the RSC's 3) among the RSC's themselves 4) from the driver/operator through the RSC to the DOE.

Diffraction of Responsibility

Complex organizations run the risk that their very complexity will cause a vital piece of information to go unreported or unknown. The specialization that occurs in complex organizations is not an unmixed blessing. The "That's not my department!" syndrome is very common in large organizations and in many cases contributes to accidents. In the case of the White Metal Box leaks, the DOE's report said: "DOE-FEMP and FDF oversight was hampered by a multiplicity of systems for tracking corrective actions."

308 cont. There were so many systems reporting pieces of the problem, that it was impossible for one person-or even one agency-to identify problems that would lead to a serious problem. These problems existed in a system used to manage relatively benign LLW. Clark County believes that it is equally likely that similar problems will exist in the HLW management system. As part of the transportation system description, the DOE should explain how it will avoid problems of this sort.

Displacement, Routinization, and the concern for Efficiency

Freudenburg suggests that all organizations have some problem with goal displacement. That is, the managers of an organization are likely, over time, to set goals for the organization that are dramatically different from the original goals of the organization. Freudenburg's statement should be qualified that by adding that all organizations have multiple objectives and although the primary goal of the organization may not change, the emphasis placed on certain goals will change over time. A dramatic example of this kind of failure occurred at the Davis-Besse nuclear power plant. On June 9, 1985, where, subsequent to a complete loss of main feedwater, nine abnormal events, including both operator errors and equipment failures, resulted in a loss of all sources of feedwater to the steam generators and a dryout of both steam generators.

The shift supervisor knew that this action required a long cleanup effort and would result in a large economic loss. In spite of this requirement in the emergency operating procedures, the shift supervisor did not initiate the feed and bleed; he waited for the equipment operators to recover the auxiliary feedwater system. This incident demonstrates that safety policies set the priority of operator actions long before an emergency.

The last aspect of displacement mentioned in these comments will be routinization. The problem of displacement is widely recognized in the literature of organizational behavior, but is not at all addressed by the risk assessment presented in the DEIS. The DOE should describe how it would prevent its transportation system from decaying over time. An example of how automated safety systems can engender the wrong attitude is shown by this example:

> "..on March 31, 1987 the NRC ordered the core shutdown of Peach Bottom-3 of the Philadelphia Electric Company on the basis that plant operators had been observed sleeping or being inattentive at their posts repeatedly, perhaps with the knowledge of immediate or higher level supervisors."

Clark County believes that DEIS risk assessment must incorporate organizational factors in order to be regarded as a credible assessment of the risk of transporting waste. The DOE must provide a more complete description of the transportation system that will move the waste. That system description must incorporate sophisticated assessments of the human and organizational problems associated with the packaging, handling and transportation of HLW. The risk assessment must recognize the considerable work done that indicates that conventional risk assessment methodologies do not provide a sufficiently comprehensive and supportable description of the risks of transporting high-level waste.

Interaction with Other Federal Programs

309... The DEIS is insufficient because it fails to consider how the Yucca Mountain Program may impact other federally mandated programs that are ongoing in Clark County, Nevada. The best example of this is the issue of air quality. Clark County is nonconforming for Federal air quality standards for both ozone and particulate matter emissions. Construction of rail lines or heavy haul infrastructure proposed in the DEIS will have an effect on air quality in Clark County. It is likely that the Regional Transportation Plan, the Statewide Implementation Plan and Transportation Improvement Program will all be affected by the construction of the infrastructure

309 cont. necessary to support the Yucca Mountain Project. The DOE must establish a provision to perform a conformity analysis for the proposed projects necessary to demonstrate that these construction activities will have no impact on Clark County's air quality. Other federal activities related to the environment, endangered species, flood control and land management must also be addressed by the DEIS.

310 Another issue is ongoing interaction between the Bureau of Land Management and the local governments in southern Nevada and California. Although the BLM manages most of the land in the region, the BLM has made agreements with various local governments in the region. It is likely that major construction of rail lines, heavy haul roads, and intermodal facilities will conflict with these agreements. The DEIS does not address the issue.

Types of Incidents

311 The DEIS does not address the reasonably foreseeable range of impacts. Based on past history, it is possible to make some inferences about what those will be. Reports on incidents involving the transportation of radioactive materials are reported in the Radioactive Material Incident Report database maintained by Sandia National Laboratories. There have been 72 incidents involving transporting radioactive materials between 1949 and the present. The 72 incidents can be characterized as follows:

- 4 incidents of accidental radioactive material contamination beyond the vehicle
- 4 incidents of accidental radioactive material contamination confined to the vehicle
- 13 incidents of traffic accidents, resulting in no release or contamination
- 49 incidents of accidental surface contamination
- 2 other incidents were mentioned in papers but descriptions are not available.

Eight incidents of radioactive material contamination (between 1960-1984) involved leaks of water, liquid, or (reported as) coolant/moderator from casks, which were discovered during shipping. Description of the events and equipment are insufficient to evaluate the failure mechanisms or sources of contamination. Each of the reported incidents is described in the chart below:

Reported Incidents Involving Spent Nuclear Fuel Shipments 1949 to Present (72 incidents by type)

Date	Mode	Incident Description
Radioactive material contamination beyond the vehicle (4 of 72 incidents):		
6/2/60	Rail	Leak from cask, small areas at three rail yards contaminated, no runoff or aerial dispersion.
8/21/62	Truck	Cask leakage, trailer and small portion of road contaminated.
11/11/64	Truck	Cask leakage-, trailer, packages, and terminal contaminated.
1/27/84	Truck	Slow drip from bottom front end of empty cask while stored in transportation terminal
Radioactive material contamination confined to vehicle (4 of 72 incidents):		
11/20/60	Truck	Small leak from cask onto trailer floor, result, of shifting cask, contamination confined to vehicle.

9/22/61	Truck	Leak from cask onto trailer floor, result of shifting, contamination confined to vehicle.
12/10/63	Rail	Cask leakage, cask contaminated, contamination confined to trailer.
7/4/76	Truck	Pinhole leak of, reported as, coolant/moderator on outside jacket of cask. Shipment continued without risk to public.
Transportation accident no release or contamination (13 of 72 incidents):		
12/1/56	Truck	Slid off icy road and overturned, 2 casks, 1 fell off trailer, no damage, no release.
1/29/57	Rail	Uncoupling, damage from debris, no release.
4/15/60	Truck	Trailer unhitched from tractor at 5 mph, no release.
11/15/60	Truck	Truck jackknifed, struck station wagon, no release.
12/7/60	Rail	Engine backed into cask car ' on siding, no release.
7/14/61	Rail	Minor derailment at 10-12 mph, no release.
12/8/71	Truck	Truck left 'road and cask thrown off, no release.
3/29/74	Rail	Derailed tank car struck cask car in yard, empty cask, no release.
2/9/78	Truck	Trailer buckled from weight, no release.
8/13/78	Truck	Empty cask broke through trailer bed, no release.
12/9/83	Truck	Tractor separated from intermediate set of axles, remained connected to trailer, no release.
3/24/87	Rail	Train struck automobile at rail crossing, no release.'
1/9/88	Rail	One set of rail car wheels derailed when switching tracks, empty cask, no release.
Surface contamination (49 of 72 incidents):		
1/24/74	Truck	Surface contamination on shipping pallet.
2/26/74	Truck	Surface contamination on pallet and truck, empty cask.
4/29/74	Truck	Surface contamination on pallet.
12/11/74	Truck	Surface contamination on pallet.
12/23/74	Truck	Surface contamination on pallet.
1/13/75	Truck	Surface contamination on cask.
2/27/77	Truck	Surface contamination on lifting yoke, empty cask.
4/13/77	Truck	Surface contamination on trailer, empty cask.
5/3/77	Truck	Surface contamination on empty cask.
5/12/77	Truck	Surface contamination on empty cask.
5/16/77	Truck	Surface contamination caused by small crack in impact limiter.
7/26/77	Truck	Surface contamination on empty cask.
8/3/77	Truck	Surface contamination.
8/23/77	Truck	Surface contamination on cask.
2/16/78	Truck	Surface contamination caused by open drain valve, empty cask.
2/27/78	Truck	Surface contamination on empty cask.
5/16/78	Truck	Surface contamination on empty cask.
7/24/78	Truck	Surface contamination on empty cask.
7/29178	Truck	Surface contamination on cask.
8/1/78	Truck	Surface contamination on cask.
8/7/78	Truck	Surface contamination on cask.
11/27/78	Rail	Surface contamination on empty cask, yoke, and rail car caused by defective valve or closure.
3/28/79	Truck	Surface contamination on empty cask and trailer.
4/2/79	Truck	Surface contamination on cask.
4/2/79	Truck	Surface contamination on empty cask.

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4/3/79	Truck	Surface contamination on tire chains, hold-down chains, and tighteners caused by loading or unloading cask from trailer.
4/4/79	Truck	Surface contamination on empty cask.
4/5/79	Truck	Surface contamination on trailer, empty cask.
7/23/80	Truck	Surface contamination on empty cask
8/25/80	Truck	Surface contamination on cask.
2/2/81	Truck	Surface contamination on empty cask and trailer
5/30/81	Truck	Surface contamination on cask and trailer.
5/31/81	Truck	Surface contamination on empty cask.
6/2/81	Truck	Surface contamination on cask. Third consecutive instance of surface contamination, NRC suspends further shipments.
8/25/83	Truck	Surface contamination on. empty cask.
9/30/83	Truck	Surface contamination on empty cask.
10/21/83	Truck	Surface contamination on empty cask.
1/7/84	Truck	Surface contamination on empty cask.
1/25/84	Truck	Surface contamination on empty cask.
2/24/84	Truck	Surface contamination on cask.
1/11/85	Truck	Surface contamination on trailer, empty cask.
2/3/85	Truck	Surface contamination on cask.
7/8/85	Truck	Surface contamination on empty cask.
2/28/86	Truck	Surface contamination on empty cask.
7/29/86	Truck	Surface contamination on cask.
7/29/86	Truck	Surface contamination on empty cask and trailer
8/19/86	Truck	Surface contamination on cask.
10/15/91	Truck	Surface contamination on empty cask.
8/14/92	Truck	Surface contamination on cask.
Unknown (2 of 72):		
1965-1967	One incident, details not available.	
1968-1970	One incident, details not available.	

Different Fuel Ages

312 The DEIS should consider the radiological health effects of fuel of different ages. The DEIS analyses only twenty-five year old spent fuel. This older fuel, while still dangerous, does not pose the same risk as newer five and ten year-old spent fuel. As spent fuel ages it loses some of its radioactivity and poses a less significant health risk. The health risks for SNF that has cooled for five years are significantly different from SNF that has cooled for twenty-five years.

By bounding the analysis for different fuel ages, the DEIS will demonstrate the radiological health effect of differently aged fuel on the affected population. This analysis will establish the need to ship only older fuel and ensure proper development of the embryonic SNF packaging and handling systems. Failure to perform a bounding analysis on the age of the spent fuel will leave open the question of the age of the fuel shipped and the possible health effects fuel of different ages may have on effected populations.

Population and Employment Estimates used in the DEIS

313... The DEIS' analysis of the human health risks of transporting waste through Clark County is insufficient. The DEIS understates the risks because of a failure to realistically describe the population of the affected area. Specifically, the DEIS underestimates the current population of

313 cont. Clark County, the likely size and direction of population growth in Clark County, and the specific sensitive populations.

Current Population

The DEIS defines the affected population as those Clark County residents living within .5 miles of the route. Unfortunately, the DEIS relies on 1990 census data, although data that is more current was available. The most current demographic information was readily available from a number of different sources in the county and should have been consulted by the DOE in preparing the estimates. This is an important issue because of Clark County's rapid population growth as shown in Figure 10:

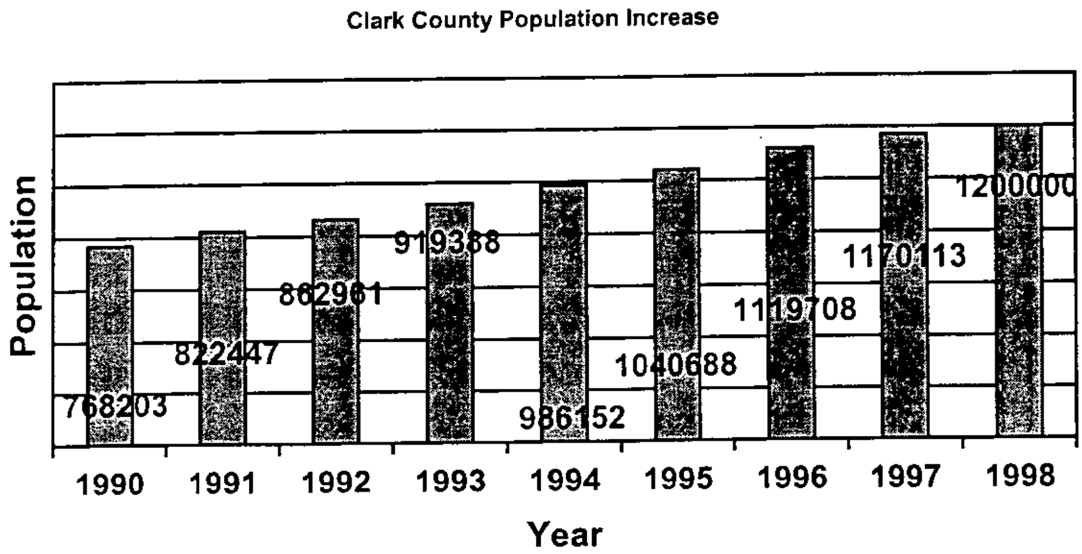

Figure 6 Population Growth in Clark County

313 cont. The failure to account for Clark County's population changes indicates that the DEIS underestimates risk. The DOE response will undoubtedly be that the 1990 Census remains the only official estimate of the population of Clark County. In many parts of the United States and indeed in Nevada, this is a reasonable assumption. In the case of Clark County, Nevada, however, that assumption is not reasonable. No responsible authority in the region uses the 1990 census for any planning purposes. Utilities, the school district and local planning agencies have all come to rely on the consensus estimate of the population.

The changes in Clark County's urban population have significant impacts on the exposed population considered in the DEIS. The population living within .5 miles of likely nuclear waste routes through urban Clark County using the 1990 census data is 88,745. The estimate of that same population using the year 2000-population estimate is 154,792, almost twice the 1990 population.

Even the Nuclear Regulatory Commission in its recent rulemaking, felt compelled to adjust the population figures to provide a more realistic appraisal of the public health risk. The DEIS did not take even this modest step. Based on these figures, the Department of Energy's analysis is misleading. To remedy the situation, the DOE, prepare a new EIS that uses the most relevant

313 cont. population figures when the 2000 Census becomes available. The current DEIS provides, at best a lower bound of the health risk.

Population Growth

Due to Clark County's rapid growth and uncertainties about the DOE's program, the DEIS should have based its risk estimates on a responsible forecast of population along the potential routes. There is no clear indication when the DOE will be in a position to ship high-level waste to Yucca Mountain. The consensus forecast for the County's population through the year 2020 is:

Year	Population
2000	1355368
2005	1640444
2010	1874431
2015	2046229
2020	2178046

313 cont. The population living within .5 miles of likely nuclear waste routes through urban Clark County using the 1990 census data is 88745. The estimate of that same population using the year 2020 population estimate is 372579, more than four times the 1990 population used in the analysis contained in the DEIS. Population forecasts for the area surrounding the likely radioactive waste routes are readily available and should have been consulted in the preparation of the DEIS. The DEIS underestimates the human health effects to Nevada's population by a considerable degree.

Population Distribution

In 1960, the State of Nevada produced tourist map of Nevada that indicates the Nevada Test Site (NTS) is 100 miles northwest of urbanized Clark County. Recent briefings by DOE staff describe the NTS as being 65 miles northwest of urbanized Clark County. This change is due to Clark County's growth. It suggests that the direction in which Clark County's urban area is growing should have been an important consideration in preparing the EIS.

The valley in which urban Clark County rests is geographically constrained. That is, the physiographic features of the region force human activity to take place in certain areas rather than others. Future population growth in Clark County must take place along potential HLW transportation routes. Urban Clark County has outgrown its original bounds and one of the most contentious issues in the region is the disposal of land from the US Bureau of Land Management (BLM). The original boundaries for urban Clark County have been adjusted several times to account for this growth. The map in Figure 11 depicts these changes.

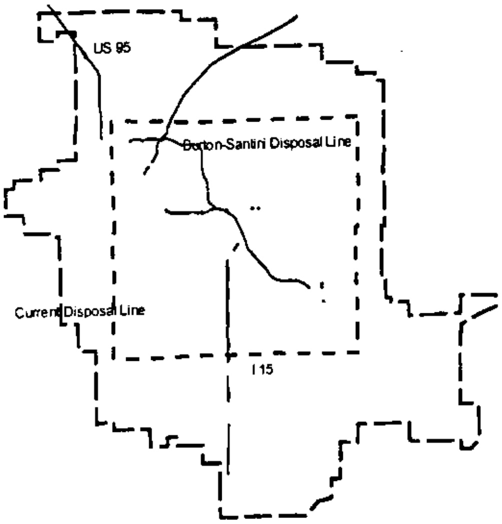

Figure 7 BLM land disposal boundaries in Clark County

313 cont. Any future population growth that occurs in Clark County will take place along likely HLW transportation routes. Because of land use plans and zoning restrictions, the nighttime population density along the beltway will be similar to the urban core densities. The only foreseeable difference in population density between the routes through Clark County will be in employment. Unfortunately, the DEIS does not consider employment population data in any of the calculations. These data are readily available from Clark County. The DEIS should anticipate the likely population growth in Clark County when preparing its risk estimates.

Past experience suggests that the center of gravity of population in urban Clark County will continue to shift to the northwest. This phenomenon has already occurred in the City of Las Vegas. It is likely that the Population growth along the route will have two effects. The first and most obvious is that the number of people exposed to radioactivity due to the proposed action will increase. The second is that the risk characteristics of the transportation routes through the area will change. The ongoing construction of homes and businesses will create heavy truck traffic and continual construction on the roads in the area. Construction zones typically increase accident rates by 50%. The DEIS fails to consider this substantial and imminent threat to public health and safety.

Special Populations

The special populations used for these comments are derived from the Clark County Hazardous Materials Emergency Response Plan for 1998. This report is prepared by the Local Emergency Planning Committee (LEPC) to support emergency management activities. The sensitive population section of the report describes facilities that contain difficult to evacuate populations. The DEIS completely ignores the significance of special populations.

Nonresident Population

A special population of particular concern to Clark County is the nonresident population. From 1991, the number of tourists visiting Clark County grew from 23 million to 33 million. The occupants of these hotels are also at risk and should be included in the population total. Along the currently existing legal weight truck route (which for an unknown reason the DEIS did not analyze) there are 17 hotels within .5 miles of the legal weight truck route. Preliminary estimates

313 cont. indicate that approximately 6,000 hotel rooms are within .5 miles of potential routes through urban Clark County. Besides the human health considerations, there are two additional concerns with regard to the DEIS.

The first of these is that the nonresident population contributes to higher accident rates. Approximately 40% of the 33 million visitors to Clark County arrive by car. These drivers are unfamiliar with the road network and make a significant contribution to accidents in the valley. Most traffic accidents are caused by drivers unfamiliar with the area in which they are driving. Clark County's tourist population presents an additional accident risk that was not considered by the DEIS.

Another concern for Clark County is the problem of evacuating these nonresidents, should an accident occur. There is no discussion in the DEIS of the size of the area that may have to be evacuated or for how long that evacuation must last. The problem of evacuation in case of a radioactive emergency has been studied by the DOE and the benefits of these studies should have been applied in the DEIS. Depending on the location and size of the plume, potentially thousands of nonresidents may have to be evacuated or relocated within Clark County. The likely effect of an evacuation are considered in another section of these comments, however, it is important to point out that the problem of controlling the evacuation of a highly mobile nonresident population is extremely difficult and could easily cause impacts to the community that were not considered in the DEIS.

Schools

The DEIS does not consider the problem of radiation exposure to schoolchildren. There are currently 37 schools within .5 miles of a potential nuclear waste route in Clark County. The number of schools near these routes will increase because new schools will be constructed along the beltway to service development in the area. The risk analysis presented in the DEIS does not consider the effects of radiation on the children attending these schools. A supplemental report that presents a radiological health examination of the effects of radiation on children attending schools adjacent to nuclear waste routes should be performed.

Health Facilities, Jails, Special Events Centers

Analysis of the Potential HLW routes indicates that the Columbia Sunrise Hospital in Summerlin is the only health facility within .5 miles of a potential nuclear waste route. No jails, group homes, drug treatment centers or senior health centers were identified. Although no special event center was identified within the .5-mile distance, Clark County believes the Las Vegas Speedway should be considered as an effected facility. The speedway is adjacent to Interstate 15. The parking lot for the Speedway falls within .5 miles of the route. In case of an accident, it is likely that the Speedway will be affected in some way.

RADTRAN Analysis

314... Clark County believes the computer codes used by the DOE to assess risk are not applicable for the kind of analysis required to assess risk properly. Although the RADTRAN computer model has been found to be legally sufficient, this took place before the advent of the microcomputer revolution and the widespread availability of inexpensive, accurate geographic data. The DOE's risk assessment system is antiquated when compared to even the most rudimentary desktop Geographic Information Systems. The DOE should postpone any further risk assessment unless the data and the risk models are adequate to compare routes on a link-by-link basis. The

314 cont. RADTRAN computer code used by the DEIS is not capable of such fine distinctions. Some of the areas the DOE should address in its risk estimates are:

Statistical Vulnerability of Low-Probability Estimates

A serious problem with the approach to risk assessment contained in RADTRAN is the inability to verify the "worst" possible threat. Because there is no database from which to draw inferences, the risk numbers produced by RADTRAN may be fundamentally flawed. The record of the nuclear industry is often cited as proof that transportation is safe. However, the characteristics of the transportation campaign for moving high-level radioactive waste are fundamentally different. Since empirical operating experience is limited, we have no scientific basis for "proving whether the estimated probabilities are too low or too high."

Environmental Justice

315 The environmental justice section of the DEIS clearly demonstrates the failings in the DOE's approach to impact assessment. The DEIS indicates that because there are no impacts on the population at large, therefore, there can be no impact on minority populations. This violates the DOE's own directives for implementing environmental justice programs and is at variance with the bets practice in the field. The DOE failed to make a serious effort in this area. In order for the DOE to have credibly analyzed environmental justice along pertinent transportation routes, the DOE must produce a new DEIS that contains documentary evidence of the DOE's outreach efforts and their effectiveness in engaging minority communities along the transportation corridors. It is vital that these communities be part of a meaningful dialogue about the risks of the program.

Emergency Management and the Maximum Reasonably Foreseeable Accident

316 The DEIS is insufficient because it fails to provide emergency responders with the information necessary to identify the equipment, training, facilities and personnel necessary to respond to an accident.

598 The DEIS indicates that the DOE prepared a description of the Maximum Reasonably Foreseeable Accident (MRFA) that describes the most severe accident liable to occur to a cask being transported from a reactor to Yucca Mountain. However, none of that information is provided in the DEIS. Emergency management impacts are a critical component of the EIS. The DEIS must provide an unambiguous description of the Maximum Reasonably Foreseeable Accident as well as the likely continuum of lesser accidents that may require local emergency response assets.

Institutional Coordination for Emergency Management

317 Once local emergency response staff has enough information to adequately describe their personnel, equipment, facilities, and training requirements there is still a considerable problem managing and coordinating emergency response training and funding. The complexity and national impact of this multi-billion dollar, 30-year program are not remarked upon by the DEIS. The DEIS fails to acknowledge any role for the Federal Emergency Management Agency (FEMA). The DEIS must describe specific responsibilities for providing, managing, and maintaining emergency response capabilities sufficient to respond to the proposed action. This statement must define: responsibility for emergency management and response training, responsibility for mitigating accidents, and responsibility for administering funds for emergency response assistance. The DOE must provide specific timeframes, dollar amounts, and agency responsibilities for providing emergency response assistance.

Land Use Conflicts

473 The DEIS ignores the rapid and substantial changes in Clark County's land use. The DEIS describes a program that potentially has enormous impacts on the economy of Clark County. In terms of likely land uses, the DEIS ignores substantial projects that should have been addressed. The City of Las Vegas' plans for growth hinge on development at the interchange of US 95 and the northern beltway. What will be the impact of heavy haul transportation being driven through the heart of the Las Vegas Town center project? Summerlin is the largest planned community in the world. Only one third of it has been constructed. Will land values remain high if heavy haul transportation takes place through this important retirement community? The intermodal sites proposed for Jean and Sloan are in full view of the Hotels located at Jean. The proposed intermodal sites near Apex may forestall any other land uses in the area.

Despite the intense regional growth, the DOE has failed to coordinate with or receive input from Clark County or any of its jurisdictions. Other major concerns that should have received attention in the DEIS are impacts on North Las Vegas due to the acquisition of 7,500 acres by the City of North Las Vegas and the rapid growth of Mesquite, Nevada.

318 Another area in which the DOE has failed to examine land use conflicts is in land management. Although the routes identified by the DEIS are not on private land, the Bureau of Land Management (BLM) has agreements about the use and disposal of the land required by some of the routes that would be violated by the Proposed Action. The DEIS will remain insufficient until a complete inventory of land use and land management impacts are addressed in the document.

Cumulative Effects

319 The cumulative effects portion of the DEIS understates the scale and complexity of the cumulative impacts of the DOE's waste disposal program. Despite assurances in the Waste Management Programmatic Environmental Impact Statement, the DEIS does not contain an authoritative examination of the cumulative impacts of both DOE disposal programs on Nevada and Clark County. According to some estimates, the shipment of Low Level Radioactive Waste from DOE defense sties across the nation to the Nevada test Site will last for approximately 70 years. The waste will be shipped by truck, and may be shipped through the most densely populated and sensitive parts of Clark County. The LLW shipping campaign will require up 12 trucks per day for the entire 70 years of the program. The chart in Figure 11 depicts the recent LLW shipments through Clark County to the Nevada Test Site.

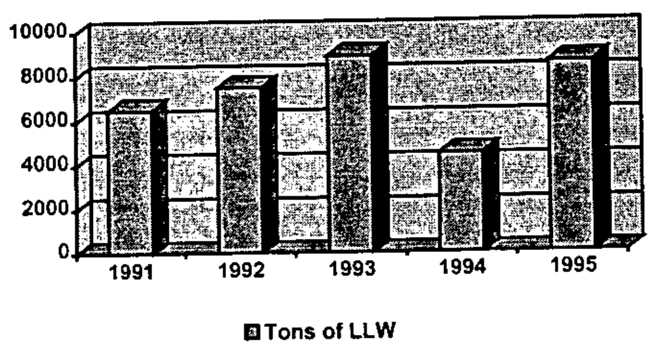

Figure 8 Low Level Radioactive Waste Shipped to NTS

320... The DOE has already established a poor record of accomplishment for managing and transporting LLW in Clark County. As indicated above, the DOE has transported at least five and possibly

320 cont. more leaking containers of LLW through Clark County to the Nevada Site. Efforts to choose routes that minimize impacts on Clark County have been treated with defiance and obstruction on the part of the DOE.

321 The DEIS provides no information about the context in which SNF will be transported. There is no information about other hazardous commodities on the roads and railways. There is no discussion of the substantial impacts of the DOE's LLW disposal program on Clark County and the likely relationship between the LLW and SNF disposal programs.

To rectify the substantial omissions in the DEIS, the DOE prepare a supplemental statement of cumulative impacts that describes the current context in which SNF will be transported. This additional statement must address: the current hazardous materials shipments in urban Clark County and rural Nevada for both rail and truck modes, it must describe the process used to identify and measure cumulative impacts and it must measure those impacts

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ATTACHMENT D

COMMUNITY INVOLVEMENT TRACKING SYSTEM [CITS]

ATTACHMENT D

COMMUNITY INVOLVEMENT TRACKING SYSTEM [CITS]

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Historical Comments on the Yucca Mountain Program - 1988 to January 2000

322 For more than a decade, Clark County has recorded comments pertaining to the Yucca Mountain Project and it's potential impacts on Clark County. The comments date back to 1988. From the very beginning, great concern has been expressed by Clark County officials, staff, citizens and other commenters. Specific issues raised in the comments include: the need to acknowledge and assess the impacts on Native Americans; cumulative impacts; issues to be addressed in the EIS; emergency response considerations; environmental impacts; environmental justice; funding; land use; perception-based impacts of DOE activities; performance assessment; planning considerations; public participation; regulatory standards; schedule & licensing; socio-economic impacts; storage; transportation; and trust issues.

From the comments recorded, it is clear that not only Clark County, but also its citizens, are very concerned about the negative impacts that the Yucca Mountain Program could have on Southern
323 Nevada. Comments relating to cultural and historical resources, for example, urge DOE to be very serious about their handling of Native American issues. The DEIS however, makes little mention of Native American issues other than to say that there are some issues that won't be
324 addressed. Requests for a review of the effects of past DOE (and predecessor) activities in
325 Southern Nevada have not been addressed in the DEIS. Others asked that DOE address inequalities and the "political" aspects of the issue but they were not addressed in the DEIS. And the comments go on.

A complete list of the comments follows. These comments are very applicable to the DEIS.
326 Many of the concerns raised early in the Yucca Mountain Program have been ignored.

The comments are organized by general categories. Early comments did not have dates associated with them, but beginning with 1992 the dates of the comments are known and noted.

Cultural and Historic Resources

	Date	Comments
327	05/01/1997	Commenters stated that the EIS should acknowledge and assess the differences between Western civilization and Native Americans in terms of: their relationship to nature; Native American ties to the land (cannot relocate because of contamination); and cultural implications in the aftermath of a radiological accident.
328	05/01/1997	Commenters requested that the EIS identify and consider all relevant legal issues. These Commenters asserted that Yucca Mountain and surrounding lands belong to the Western Shoshone Nation, according to the 1863 Treaty of Ruby Valley, and that all legal issues involving Indian land claims have not been resolved. The EIS should examine: (1) the legality (based on the 1787 Northwest Ordinance, the 1848 Geneva Convention, the 1848 Treaty of Guadalupe, the 1861 Act to Organize the Territory of Nevada, and Articles 3 and 6 of the Constitution of the United States), (2) land disturbances for construction of rail lines, and (3) the impacts to negotiations on land claims of the proposed action (including transportation) in light of the Ruby Valley Treaty and international law.
329...	05/01/1997	Commenters called for the EIS to act as a forum to enable DOE to live up to its commitments to treat Native American Tribes in a government-to-government manner,

329 cont. noting that the EIS must assess impacts on tribal trust resources, and assure that tribal government rights and concerns are considered. As part of this forum, Commenters noted that the EIS should: evaluate the attitudes and options of Native American people toward the repository program, the DOE management of the program and other relevant activities; confer with Native Americans to protect sacred burial sites pursuant to existing law; identify natural resources of value to Native Americans and provide a means to avoid any impacts; consider that the site is within the ancestral territory of the Western Shoshone Tribe, and consult with the Tribe to address issues of minimization, degradation, and devastation; and evaluate Western Shoshone land claims relative to DOE rights-of-way acquisition, location of burial sites, ceremonial sites, and other site-specific cultural resources within rail corridors.

05/01/1997

330

Commenters stressed that the EIS should fulfill commitments made in. the 1986 Environmental Assessment relative to "potential for impacts on Native American Cultures" from the construction of the repository and the transportation of SNF and HLW (including ancillary features). The EIS should include an historical description of Native American experiences in the areas affected by the repository program, including the issues of land claims, treaty obligations, federal laws relating to cultural and religious rights of Native Americans, unsettled political and legal issues, and the potential applications of Indian law to repository issues. Impacts that must he assessed, for all Native American communities both in Nevada and nationally, include: economics (economic structure, direct/indirect employment, spending, public service effects, land use conflicts); infrastructure; emergency response/preparedness requirements (including the lack of medical facilities); state/tribal relationship effects that may be caused by state routing or risk management decisions; implications for tribal sovereignty; Native land claim issues and impacts; religious aspects; political activities; Native American relations with other governmental entities (neighboring rural and urban communities, state/local/federal agencies) and quality of life (psychological stress). In addition, the EIS should consider Native American views as to what constitutes an acceptable impact on nature.

05/01/1997

331

Commenters requested that the EIS evaluate cultural resources nearby Yucca Mountain and along proposed regional rail/heavy haul corridors (Carlin and Jean routes, in Lincoln and Esmeralda counties, historic Palisade- Eureka route) given the proposal to construct and operate the repository system. More specifically, commenters indicated that the EIS should consider historical and prehistoric sites, paleontologic resources, and Native American land claims and religious freedom issues. Analyses must also be based on Class III field surveys, as well as other forms of research.

05/01/1997

332

Commenters, representing Native Americans, requested more formal involvement in the overall NEPA process to ensure that tribal rights and concerns are considered prior to decision-making or Departmental action. Many commenters cited: (1) the DOE's Indian policy regarding government-to-government relations, (2) tribal sovereign rights to regulate tribal lands and resources, and (3) cultural resource laws (National Historic Preservation Act, Native American Graves Protection and Repatriation Act, Archaeological Resources and Protection Act) as appropriate justification for greater involvement. Specific involvement issues raised included routing decisions and transportation planning, development of alternatives, impacts to ancestral artifacts, ecosystem impacts, the development of a plan to ensure Native American review of the draft EIS, and financial assistance for consultation purposes.

Cumulative Impacts

Date	Comments
05/01/1997 333	Commenters expected the EIS to analyze the cumulative environmental and radiological risks and hazards from all past, current and proposed radioactive waste and special nuclear materials activities at Yucca Mountain, the NTS, and surrounding environs. Commenters identified commercial and DOE-owned SNF, foreign research reactor SNF, HLW, Greater than Class C waste, special case waste, LLW, TRU waste, and special nuclear materials that should be included in these analyses. These analyses are also expected to consider transportation (all communities and Indian Nations, all routes, all modes, all rail spurs), storage and/or disposal, and treatment. More specifically, commenters requested that the EIS address: (1) both the 70,000 MTHM limit and the total estimated 85,000 MTHM of SNF, (2) all DOE-owned SNF, (3) all foreign research reactor SNF (~19.2 MTHM), (4) ~28,372 canisters of HLW (to be modified to reflect decisions from Hanford's tank waste EIS), (5) ~70,000 cubic feet of Greater than Class C, and (6) ~2.6 million cubic feet of special case waste. Commenters requested that the cumulative impact analyses assess the significance of direct and indirect long-term effects on the human and natural environment, such as impacts to human health (to "downwinders," local communities, and workers), ecosystems (with reliance on the NTS resource management plan), air quality, soils, socio-economics, and local and regional groundwater resources. Impacts should be developed in consideration of: (1) contaminant levels from past weapons testing and associated research and development activities at NTS, (2) waste disposed of or planned for disposal at the NTS, (3) waste disposed of at the Beatty low-level waste site, (4) ongoing waste management, environmental restoration, and decontamination and decommissioning activities at NTS, (5) military operations, and (6) discharge of toxic metals from abandoned mines. Cumulative impacts must be assessed in time frames that range from 1,000 to 1,000,000 years. Commenters requested that the cumulative impact analyses be supported by credible scientific data, including the development of baseline health data, which have undergone peer review. In addition, the way in which equity and fairness issues are involved should be considered.
05/01/1997 334	Commenters believed that the repository EIS should address public health and safety issues including- - baseline and future health assessments: past exposures to radiation; dangers of; radiation; releases of radioactivity; exposure pathways and scenarios; effects of radiation on Native Americans; agriculture; human error and nuclear proliferation.
05/01/1997 335	Several commenters requested that the EIS reveal and otherwise evaluate the effect of past DOE activities in southern Nevada. More specifically, commenters requested: (1) a history of decisions by DOE (and DOE -predecessors Energy Research and Development Administration and the Atomic Energy Commission) that have affected the health and safety of organisms within a 700-mile radius of Yucca Mountain, (2) a summary of Research conducted on the effects on health and safety from radiation exposure, (3) a list and summary of past and pending litigation on radiation exposure, (4) that the EIS examine the global risks from nuclear-related activities, and environmental restoration and waste management at the NTS, including the transportation of wastes, and (5) that the repository EIS be coordinated with the EIS on the NTS.

	EIS Date	Comments
	06/18/1992	Agreed with all points but argued that GIS can be a critical and innovative component
336	11/22/1995	DOE needs an interactive data collection, management, and study methodology for various EISs that they are doing. This would help local gov't monitor DOE processes.
337	11/22/1995	Draft comments NOI for Yucca Mtn. EIS. Since DOE plans to use much of EIS data to support license they must use QA/QC techniques required by licensing process for EIS. DOE needs to share this plan with stakeholders. Public can use to evaluate EIS findings
338	05/01/1997	One commenter called for the EIS to address liabilities in the absence of the Price Anderson Act.
339	05/01/1997	The No Action Alternative should include activities in addition to stopping work at Yucca Mountain and Continued storage of SNF and HLW at the generator sites. Other activities to be evaluated include: (1) long- term storage and maintenance of SNF and HLW (also Greater than Class C), (2) the development and use of dry cask storage, (3) phase-out and replacement of nuclear power with alternative sources, (4) all SNF and HLW (not limited to 70,000 MTHM), and (5) site-specific activities (e.g., closure dates, handling options, on-site storage, SNF/HLW inventory). Several commenters stated that the No Action Alternative should not include discussions of the future of the nuclear energy industry, including future construction and operation. Some commenters stated that the No Action Alternative must be part of the EIS, while other commenters stated that the No Action Alternative should not be part of the EIS because it was not part of Congress's intent. One commenter stated that the No Action Alternative should be the only alternative evaluated in the EIS.
340	05/01/1997	Several commenters suggested that the EIS, Record of Decision and Mitigation Action Plan include a comprehensive identification and evaluation of specific measures to mitigate each repository system impact, both from accidents and non-accident conditions. Further, the mitigations must demonstrate that the measures will be sufficient to offset or otherwise minimize negative effects on the State of Nevada, local communities and other states and communities along transportation routes. These commenters believe that monitoring, avoidance, minimization, rectification, and reduction or elimination must be considered, as well as consultation with other appropriate agencies (as opposed to promises to consult, conduct further studies, only monitor, and request outside review).
341	05/01/1997	Several commenters requested that the alternatives include the management of all SNF and HLW or more than 70,000 MTHM of HLW and SNF by: (1) evaluating larger repository capacities (e.g., maximum amount of repository capacity, 120-140,000 MTHM), (2) describing the need for and impacts of a second repository, and (3) describing how the entire foreseeable HLW and SNF inventory would be managed (e.g., treatment and storage alternatives).
342	05/01/1997	Several commenters requested that the EIS evaluate the implications of transport and disposal of SNF and HLW on national security, terrorism, and proliferation of nuclear weapons in the U.S. and abroad. Mechanisms that preclude terrorism and proliferation also should be addressed by the EIS.
343...	05/01/1997	Commenters requested that the EIS identify all waste (and waste characteristics) to be disposed of in the proposed repository. Examples of waste types that should be discussed

343 cont. (for disposal or in confirmation that they would not be disposed) included all waste types in other DOE EISs and DOE planning documents proposed for geologic disposal, Greater than Class C, special case, weapons-grade plutonium, highly enriched and Navy SNF, and West Valley SNF and HLW. Characteristics that commenters stated were important for the EIS to discuss included fuel type, age, structural characteristics, cladding, and volume of each source of SNF and HLW. Two commenters requested that the EIS identify the order in which the producers/generators would ship SNF and HLW to the repository. One commenter stated that DOE SNF (including Navy SNF) should be received early.

344 05/01/1997 Three commenters requested that the preferred alternative and options be identified in the draft EIS.

345 05/01/1997 The Action Alternatives should include (or not include) other activities besides the construction, operation (including transportation), and closure of the repository. Other activities included: (1) impacts of construction of shipping containers and waste packages, (2) infrastructure development, (3) future construction and operation of new and existing power plants, (4) additional SNF and HLW generation because on-site storage space will become available, (5) global activities associated with foreign research reactor SNF transfer, and (6) no longer generating SNF as part of the action alternatives. One commenter stated that future operation of new and existing reactors and construction of new reactors should not be part of the action alternatives.

346 05/01/1997 Three commenters stated that the description of baseline conditions described in the EIS should be those conditions that existed prior to the start of site characterization.

347 05/01/1997 A commenter recommended that the results of ecosystem-based studies on the long-term consequences of the repository to future generations be included in the EIS. The commenter further stated that if DOE's NEPA schedule is too short to include the results of these studies, then the implementation plan should describe how this information will be obtained and presented in supplemental EISs.

348 05/01/1997 Many commenters requested that DOE restructure the EIS's proposed action and alternatives stating that the NWPA does not preclude DOE from examining: (1) the need for the repository, (2) alternatives to geologic disposal (including recycling, storing wastes at the vitrification site, developing methods of waste remediation and destruction, using the waste for beneficial purposes, and launching the waste into space), (3) alternative sites to Yucca Mountain (including at-reactor dry-cask storage, interim storage, leaving foreign wastes in countries that generate the wastes thereby linking nuclear proliferation with the consequences of waste disposal), and (4) the timing of repository availability. Consistent with this restructuring, commenters suggested that the EIS evaluate the disposal of more than 70,000 MT'HM, alternatives if less than 70,000 MTHM are disposed, the likelihood of a second repository, the disposal of additional wastes (surplus plutonium, highly enriched uranium, Greater than Class C), and the impacts of developing a low-level waste repository at Yucca Mountain. In contrast, other commenters said the Congressional intent not to require such analyses in the EIS should be followed, waste forms examined should be limited to SNF and HLW, and that the no-action alternative should not be examined.

349 05/01/1997 One commenter stated that the EIS should discuss how the nuclear waste program will improve performance of DOE's technical and scientific investigations, and program
350... management to increase scientific legitimacy. Others said the EIS should discuss how public trust and confidence in the nuclear waste program (including public acceptance of

350 cont. health effects from transporting the waste) and DOE's management of the program will be achieved.

05/01/1997

351 Some commenters requested cooperating agency status for their respective organizations, based upon unique skills, expertise, knowledge, and data. One commenter requested that Council on Environmental Quality, Environmental Protection Agency, Nuclear Regulatory Commission, Department of Transportation, Federal Emergency Management Agency, and Department of the Navy be actively involved (cooperating agency or consultation) in the preparation of the EIS. One commenter noted that the Implementation Plan should address how Nuclear Regulatory Commission's NEPA policy and guidance will be addressed.

05/01/1997

352 Several commenters addressed the issue of technical and programmatic uncertainty requesting that the EIS examine the uncertainty of long-term storage; changing laws, political support, and funding (e.g., funding reductions for site characterization and the intent of some in Congress to limit site suitability studies); changing attitudes and values regarding waste disposal; uncertain repository performance; and uncertain data.

05/01/1997

353 Several commenters provided "broad" or general recommendations as to how the EIS process and document preparation should proceed. One said that the EIS should be organized by issues, rather than a traditional organization by subjects (air quality, geology, etc.), and rely on stand-alone technical reports for each issue. Another requested that the implementation plan include a list of decisions that the EIS needs to support, along with a discussion of the factors that DOE will use to make comparisons among all decision choices. Other commenters requested that the EIS be part of a comprehensive risk-management process (independently prepared and acceptable to stakeholders), and reflect scoping comments from the NTS site wide EIS and the Multi-Purpose Canister EIS, and that all commitments for mitigation be included in the Record of Decision.

05/01/1997

354 Commenters requested that the EIS justify the selection of the alternatives, and that the alternatives and options be sufficiently defined to comprehensively describe the affected environment, and to allow an equivalent analysis (between alternatives) of potential positive and negative impacts to human health and the environment (e.g., groundwater, air, socioeconomics) from routine operations and accidents during construction, operation, and closure. The types of detail identified include: (1) shipping priorities, (2) shipping facilities to be used, (3) the maximum number of shipments by mode, (4) the routes and their

355 attributes (e.g., population centers), (5) construction methods, (6) facilities used at Yucca Mountain, (7) subsurface attributes that ensure that SNF and HLW can be contained, (8) surface and subsurface operations (e.g., handling, packaging, emplacement, secondary waste handling, mitigations), (9) anticipated waste package characteristics (e.g., fuel age,

356 heat, size), (10) retrieval scenarios, (11) agency responsibilities for transportation and

514 accident/emergency response, (12) pre- and post-closure monitoring programs, and (13) institutional controls.

05/01/1997

357... In general, commenters recommended that the EIS address general policy issues relevant to the NEPA process, management of that process, and impacts due to site characterization activities at the Yucca Mountain site. The EIS must present a thorough description of the natural, social, economic, and as-built aspects of the project that are sufficient to enable delineation of subarea (i.e., specific community) impacts (including probability of occurrence and degree of consequence). Commenters indicated that preparation of the EIS required the development of a structure (or plan) for data collection, analysis, and research that is comprehensive, and relies on related project activities. Sufficient data should be collected so as to minimize, if not avoid, uncertainties and, thus, the 5-year time frame

321

Date	Comments
357 cont.	allotted for completion of the EIS should not be a requirement, but rather a guideline. This requires an interdisciplinary approach to: (1) acquire empirical baseline information; (2) acquire empirical information about potential adverse impacts; (3) reduce uncertainties through risk analysis; and (4) develop adequate plans for monitoring, managing and mitigating potential impacts for up to I million years. Commenters suggested that the extent of uncertainty must be identified in the EIS.
358	It was further suggested that a "holistic [and ecosystem] approach that analyzes the entire system around waste disposal" is appropriate to ensure environmental decision-making in the long-term context of the repository. These same commenters believe that the NEPA process, based on DOE's commitment to comply with the spirit and intent of NEPA, should provide a link between the affected public and federal resource management policy. Based on historical and current ecosystem project activities, commenters requested that the EIS describe the role and use of the data and information resulting from these activities. In addition, the EIS should not rely on subjective judgment, but must include empirically-based findings, and explain how its ongoing environmental program will compensate for the lack of process-based ecosystem simulation modeling. Some commenters suggested that the EIS include the views of those scientists and engineers that oppose the project, and that independent peer review was necessary to prepare an adequate EIS.
05/01/1997 359	Commenters requested that alternatives in the EIS address all phases (e.g., construction, transportation, operation, retrieval, closure) and major activities (e.g., emplacement, construction methods, backfill, ownership and management of transportation systems, maintenance). Some commenters suggested that alternatives be developed based on reducing exposure risk and uncertainty, increasing safety, and enhancing economic benefit.
05/01/1997 360	Commenters requested that the EIS include other alternatives such as mixed thermal loads, an isothermal- distributed load, only the high thermal load with an incremental evaluation of performance, and a retrievable-waste alternative.

Emergency Response

Date	Comments
03/27/1992	Worst case forecasts are needed. Noted difference costs for such forecasts between Tennessee/$3 million & South Carolina/$170,000
07/26/1995 361	Concerned that Clark County ER personnel is 45 minutes away. Also, concerned that Indian Springs only has a volunteer fire department and Nevada Highway patrol only gets 4 hour notice of shipments of HLW.
12/21/1995 362	Rural areas with volunteer fire staffs are likely to need help from fulltime ER agencies from the urban area. No coordinated plan for this activity is in place.
12/21/1995 363	Although some ER management activities are in place, the ability to get special equipment on site quickly is not resolved. Also, the substance, timing, and magnitude of federal assistance to local government is uncertain.
04/11/1996 364	DOE should provide in-vehicle radio repeaters, binoculars, cellular telephones and other equipment to corridor jurisdictions.

365	04/11/1996	DOE must ensure that local response agencies are able to identify and notify appropriate agencies responsible for responding to or supporting handling of accidents.
366	04/11/1996	DOE should provide preference to local public safety an ER agencies for free distribution of federal surplus ER equipment.
367	04/11/1996	Non-corridor communities should also have access to training.
368	04/11/1996	DOE should provide 2 new detection instruments per jurisdiction and ongoing calibration services in conjunction with training in corridor communities for ER.
369	04/11/1996	DOE should fund ER training for corridor communities. Provide weekend classes for volunteers and pay stipends to training participants. DOE should ensure necessary financial & technical assistance to local gov't for EM plans.
370	05/03/1996	Risk management requires knowledge of routes, federal, state and local resources, hazardous and high risk segments, special population impact needs. Roles and responsibilities must be clearly spelled out.
371	12/17/1997	Emergency response preparedness is behind schedule because of DOE's lack of route selection

Environmental Impacts

	Date	Comments
372	05/01/1997	Commenters requested that the EIS conduct additional studies of the deep aquifer system, and evaluate the pathways created by faults at and near Yucca Mountain that could allow surface water to seep through the -repository and adversely affect groundwater in Amargosa Valley, Ash Meadows, and Death Valley National Park.
373	05/01/1997	One commenter asked if the EIS will discuss monitoring of potential subsidence at the surface caused by underground excavations, and if numerical modeling of underground stresses will be conducted.
374	05/01/1997	One commenter requested that the EIS evaluate the potential for spills to penetrate into the ground.
375	05/01/1997	One commenter requested that the EIS identify paleontologic sites in Lincoln County that could be impacted by construction of the repository and the rail line.
376	05/01/1997	Three commenters stated that the subsurface rock at Yucca Mountain is rotten (crumbles easily during tunneling), or has been fractured from underground testing of nuclear weapons, and that radioactive releases into this rock must to be evaluated.
377...	05/01/1997	Many commenters asked that the EIS evaluate the impacts of seismicity, geologic structure, and volcanism on radionuclide containment and repository operations. Issues raised for consideration included: (1) the proximity of Yucca Mountain to the Walker Lane/Las Vegas Shear Zone, (2) the relationship between the Walker Lake/Las Vegas Shear Zone and the San Andreas fault, (3) the pattern of earthquakes and volcanism in the region, (4) the classification of the region as a high earthquake-hazard zone, (5) and active plate tectonics. Several commenters stated that the faults at Yucca Mountain need additional study for

377 cont. inclusion in the EIS, because they are pathways (through rupture or breach) for gases and fluids to enter and exit the repository and transport radionuclides. Some commenters questioned the reliability of predicting the size and location of earthquakes, and the accuracy and recency of geologic mapping in the region. Others wanted a detailed description of the seismic design of the facility, and an evaluation of the consequences from the largest credible earthquake, including changes in the water table. One commenter noted that large volcanic eruptions have covered Yucca Mountain and asked that the EIS examine the likelihood of similar eruptions in the future.

378 05/01/1997 Two commenters requested that the EIS assess the impacts to mineral exploration and development from the withdrawal of lands for the repository. Another commenter requested
379 that the EIS identify sites in Lincoln County for borrow material (chiefly for the railbed) and include geologic and soil maps for all potentially impacted areas in Lincoln County.

05/01/1997 Commenters believed that the EIS should evaluate the source and significance (in terms of flow and transport) of tritium found below the repository horizon. One stated that the source
380 of the tritium must be determined before the program proceeds. The other said the tritium is due to above-ground testing of nuclear weapons conducted from the late 1940s to the mid 1960s, and that the presence of tritium indicates that it has traveled rapidly through the groundwater system from testing areas. This should disqualify the site because the siting guidelines (10 CFR 960) state that "A site shall be disqualified if the pre-waste groundwater travel time along the fastest pathway is determined to be less than 1000 years."

05/01/1997 Commenters requested that the EIS evaluate the impacts from reasonable changes in the level, and the potential for elevated temperatures, of the water table at Yucca Mountain. To
381 support this issue, commenters cited the presence of "calcite opal mineral formations" along fractures as evidence of upwelling hot water, which could leach radionuclides into the environment, flash to corrosive steam in an already hot repository, and increase the risks of criticality. Another commenter noted the high temperature of the Amargosa River as evidence of high- temperature groundwater.

05/01/1997 One commenter stated that the impacts of surface flooding during construction and
382 operation of the repository should be evaluated.

05/01/1997 One commenter noted that the radiation risk to residents (Esmeralda County) of airborne
383 exposure should be included in the EIS.

05/01/1997 One commenter stated that the EIS should describe the relevant state of Nevada water rights
384 regulations and whether DOE is in compliance.

05/01/1997 One commenter requested that the nature and duration of changes in the surface ecosystem
385 at Yucca Mountain from waste-generated heat and refluxing water vapor be examined in the EIS for each alternative.

05/01/1997 A commenter indicated that the EIS should provide the technical basis to establish a groundwater-monitoring network during the pre- and post-closure phases of the repository,
386 believing that groundwater quality, quantity, and flow in the saturated and unsaturated zones at Yucca Mountain will not be adequately known.

05/01/1997 Commenters stated that the EIS, based on field surveys prior to further ground disturbance, should thoroughly examine the impacts to biological/natural resources during all phases of
387... repository development. Commenters suggested that the analyses address: (1) critical habitats for threatened, endangered, and sensitive species, including impacts from radiation

387 cont. exposure during accident-free operations and from accidents, (2) impacts to wildlife habitat
388 and migration (wild horses, bald eagles), and big game populations along transport corridors/corridor improvements/borrow areas (Big Smoky Valley, Lincoln County, Clark County, Elko region) and the loss of hunter-generated revenue, and (3) cumulative impacts
389 considering both (1) and (2).

05/01/1997 Commenters stated that the EIS must fully describe the existing environment (wells, springs, drinking and agricultural water sources including the Humboldt River, depth to
390 groundwater, water quantity and quality, spring-discharge rates), and examine possible impacts to these resources from construction and operation of regional transportation facilities and the repository, including impacts from repository failure. The region of
391 influence evaluated by the EIS should include all parts of southern Nevada and eastern California within the groundwater-flow system that contains Yucca Mountain, as well as the areas along potential regional transport routes.

05/01/1997 Several commenters requested the preparation of a programmatic EIS that would evaluate the Nation's nuclear waste policy, possibly including an independent review process. EISs
392 for related program elements would be tiered to the programmatic EIS. The programmatic EIS should include: an evaluation of major siting decisions involving co-location of both defense and non-defense storage and disposal facilities in Nevada; transport of waste, including accidental releases and incremental exposure to radiation at communities along waste-transport routes; and the impacts of nuclear power plants.

05/01/1997 One commenter called for the EIS to examine, in consultation with affected Federal and State land-management agencies, the effects on wildlife, wilderness, and public-recreation
393 areas from construction and operation of national and regional waste-transportation corridors.

05/01/1997 Commenters requested that the EIS include an analysis of existing visual quality within basins in Lincoln County and in the Elko region, and a description of the visual impact from
394 rail construction and operation.

05/01/1997 Several commenters noted that construction and operation of the repository and transportation facilities could degrade current air-quality attainment status (Lincoln and
395 Clark Counties), and that emissions of fugitive dust could impair visibility and reduce the safety of waste transport. Thus, the EIS should describe existing air- quality and meteorological conditions (severity of storms, temperature extremes, fog) in each affected area, and assess the potential environmental consequences to air quality and the extent to which meteorological conditions could affect waste transport.

05/01/1997 One commenter stated that the EIS should assess baseline and project-induced noise levels along waste-transport routes in Lincoln County and at other County sites where repository
396 components and activities would be located (intermodal transfer sites, borrow sites, highway-construction sites, and heavy-haul routes). Impacts to the quality of life and to wildlife from increased noise levels should be evaluated in the EIS.

01/26/2000 NPTE leakage in Santa Monica, CA. pertaining to the gas leakage in the water, has affected three states - California, Nevada, and Glendale (OH?) and Washington. This leakage has
397 been since 1989 and they have no way of cleaning it up. It has caused cancer in these states and has affected the water and the air. This is my concern with the Yucca Mountain Project - a similar situation could arise here.

Environmental Justice

	Date	Comments
	11/22/1995	Equity needs to be restored to nation's challenge of siting waste storage. Example, NTS Community Advisory Board influenced route choices for waste shipments to NTS.
	12/21/1995	80% of Yucca Mountain Project purchases are made out of state. Only 15% was made in Clark County.
398	12/21/1995	Can we measure and monitor whether transportation impacts are distributed equitably. Initial analysis of population distribution vis-à-vis repository impacts indicated African American/low income stakeholders will be disproportionately impacted.
	12/21/1995	The distribution of economic development benefits will exacerbate rural/urban conflict.
399	12/21/1995	The distribution of risk associated with HLW and the distribution of disadvantage populations could expose some populations to inequitable risk that can't be remedied. Thus, hurting the community fabric.
400	12/21/1995	The service nature of the Clark County economy supports are large number of minorities that could be damaged by the repository.
401	12/21/1995	Warehousing and distribution has become an increasingly important market diversification effort in Clark County. It is located primarily in the UP railroad, I-15, and NV-604 (Las Vegas Boulevard) area. This sector could be hurt by repository.
402	12/21/1995	Populations at risk include: residents; peak and average daily visitors; workplace employment population; institutional populations. Are some populations, for example, African Americans at greater risk than the general resident population?
403	05/03/1996	County feels EIS must seriously consider federal directives regarding environmental justice. 24% of county is minority (11% Hispanic/ 9% Black) and 38% along UP rail line. Native Americans live in areas adjacent to I-15 and US 95.
404	05/03/1996	Environmental justice with regard to transportation must be considered in the NTS EIS.
405	05/01/1997	Commenters requested that the EIS, as part of its environmental justice analyses, recognize that Yucca Mountain and the NTS are Western Shoshone land in consideration of the reserved right of the Western Shoshone government, not specifically granted through the Ruby Valley Treaty, and in further consideration of the United Nations Charter and Declaration Against Discrimination and Genocide.
406...	05/01/1997	Commenters noted that the EIS should fully assess equity issues (i.e., environmental justice) along all potential transportation corridors. These commenters believe that the analysis should be addressed on a site-by-site basis (e.g., each Indian Nation, African-American communities), mile-by-mile for potential disproportionate impacts on economic, ethnic, or racial subgroups of the U.S. population (Native Americans, African-Americans). Further, the analysis should consider that often these communities: (1) do not have the ability to evacuate quickly in case of an accident, and in some cases would not learn of the accident in their area, (2) need to be reeducated to the dangers of SNF/HLW, and (3) may

406 cont. receive a disproportionate exposure because transportation will avoid major cities in favor of smaller communities.

407 10/16/1997 Disproportionate risk to minorities and low income along transport corridor.

Funding

	Date	Comments
	02/25/1992	Wanted information on funding deadlines
	02/25/1992	Stated that Congress is requiring more detailed funding justification for local entities. Sites comments by Congressman Sharp that WIPP funding to New Mexico is a gift.
	02/25/1992	Notes the future funding must be submitted given DOE funding cycle.
	02/25/1992	Wanted a breakdown of funding request at the entity level
	06/11/1993	Inadequate funding has preventing Clark County from going forward with technical studies (age dating; seismic profiling; tectonics)
	10/07/1993	"Disappointed " in Clark County's action.
	10/07/1993	Comments that the movement of funds and staff by Clark County leaves "it wide open".
	10/07/1993	Concerned that Steering Committee is vulnerable because of the action on staff and funding by Clark County.
	10/07/1993	"Disappointed" that Clark County did not consult Steering Committee
	10/07/1993	Argues that the MOU is the "defining document"
	10/07/1993	Disagrees with Petterson "100 %"
	10/07/1993	Disapproved of Clark County having moved funding and transferred staff without consulting the Steering Committee.
	10/07/1993	Argues that the Steering Committee doesn't really steer
408	11/22/1995	Impacts. DOE must adequately fund local planning and address unfunded/underfunded mandates such as escorts, ER, and vehicle inspections.
409	11/22/1995	Draft Comments on NOI for Yucca Mtn. EIS. Savings from delay of EIS could be used also to complete studies of fund distribution to state, local gov't, and tribes for ER preparedness and to clarify risk. Impact assessment approaches to be used by DOE.
	11/22/1995	Draft Comments County on NOI for Yucca Mtn. EIS. EIS should be delayed until final legislation. Savings from delay should be used to complete presently-delayed DOE projects because of reduced funding, esp. route selection methodologies
410	11/22/1995	EIS must include unfunded mandate issues like additional security that county must pay for HLW transport.

411 05/01/1997 Commenters requested that the EIS identify which agencies will pay for transportation-related improvements, mitigations, and monitoring programs.

412 05/01/1997 Three commenters believe that the EIS should address construction of the exploratory shaft facilities as a de facto repository, although the suitability of the site has not been decided.

413 05/01/1997 The EIS should provide a full accounting of the past and future funding sources for the program; the potential uncertainties of continued funding from these sources and the impacts if funding is not sufficient; and analyze the fairness of the distribution between the sources. Some of these commenters felt that costs should be borne by the power companies and the ratepayers for nuclear utilities, and not by the taxpayer. In addition, costs for disposal of foreign research reactor SNF should be paid by the foreign governments.

Land Use

Date **Comments**

414 05/01/1997 One commenter requested that the EIS indicate whether all lands would be cleaned up to the same standards after an accident, regardless of ownership.

415 05/01/1997 Commenters suggested that the EIS evaluate the impacts to current land uses along the potential regional rail and heavy-haul routes. Land uses and related issues identified for evaluation include: (1) the availability of public lands, (2) the ease of obtaining rights-of-way, (3) consideration of eminent domain, (4) impacts to hunting and fishing opportunities and other recreational water uses, (5) effects on grazing allotments and livestock permittees, (6) public travel across Big Smokey Valley, and (7) potential interference with U.S. Air Force operations on the Nellis Bombing and Gunnery Range.

416 05/01/1997 One commenter requested that the EIS discuss how the repository program will be consistent with DOE's Land Facility Use Management Policy on ecosystem management, sustainable development, and stakeholder participation in decision-making. The commenter also requested an explanation of how the Yucca Mountain Project will be consistent with the Resource Management Plan being developed for the NTS and how DOE (NTS and the Yucca Mountain Project) will interface with the Bureau of Land Management's Mojave-Southern Great Basin Regional Advisory Council, as well as take into account the rangeland health standards and guidelines. Another commenter stated that the EIS must address any conflicts between DOE's proposed action and the plans, policies, and controls of Indian Tribes.

417 05/01/1997 Commenters requested that the EIS examine the effects of construction and operation of the repository and its transportation systems on federal, state, and county existing land uses (e.g., land quality, agriculture, livestock use, mineral/oil exploration, protected or otherwise sensitive lands, withdrawn areas, availability of water resources) and land use plans, policies, and controls.

418 05/01/1997 One commenter believed that the EIS should consider the extent to which communities near the repository would grow rapidly and the resulting impacts from increased demands on the use of limited private lands for residential, commercial, and industrial development.

Perception-Based Impacts

	Date	Comments
419	05/01/1997	Commenters believe that the EIS should be used to select specific transportation routes in consideration of the socioeconomics impacts from the public perception of risks. Socioeconomic impacts mentioned for analysis include interference with orderly and planned urban development, and unredeemable costs and burdens on local governments.
420	05/01/1997	Commenters suggested that the Yucca Mountain has already been selected by DOE (some commenting that underground construction was well underway), nothing will alter that selection, and the comment process and the EIS were mere formalities.
421	05/01/1997	Commenters expressed opinions that the Government of the United States (and in particular the DOE) does not have the right to impose the Yucca Mountain project on the State of Nevada, only the people have the right, and they oppose government intervention.
	05/01/1997	Commenters provided clarifications to perceived misconceptions. These misconceptions included: the definitions of HLW, the applicability of court rulings, "intermodal transfer capability" was incorrectly referred to as "intermodal transfer facility," Multi-Purpose Canisters would be shipped in Nuclear Regulatory Commission certified "overpacks" not "casks," and the purposes of the NWPA.
422	05/01/1997	Commenters expressed a general distrust for the DOE, in part based on a history of lies, mistakes, and broken promises. Commenters also criticized the distorted information provided by anti-Yucca Mountain groups and encouraged the DOE to use properly trained and experienced scientists and engineers to inform the public. Some commenters criticized both sides of the debate and encouraged the formation of an unbiased panel of scientists and engineers.
423	05/01/1997	Commenters believe that the EIS should address perceived risks (stigma, psychological, sociological, community behavior, cultural, spiritual) due to the negative impression of a repository, other related effects (transportation gridlock), and the potential resulting economic losses from the construction and operation (routine, accidents, sabotage) of the repository, when considered on a national basis (San Luis Obispo), and on a local (nearby the site, Clark County) and regional basis (transport corridors). Mitigation measures (compensation from loss of tourism and business and decreasing property values, creation of insurance programs, compensation distribution plans, purchase of private property, business and personal relocation) to offset perceived risks also should be addressed by the EIS (in part, based on City of Santa Fe vs. Komis). More specifically, the EIS should evaluate and mitigate the real and perceived risks for each affected community (including Native American communities) and social/cultural groups or organizations, on: socioeconomics, tourism and recreation (visitor/entertainment sector, gaming, conventions/meetings business, commercial activity), retirement and quality of life, county and community property values, local emergency management capabilities and effectiveness, tax base, ability to maintain community services, and the democratic way of life.
424	01/04/2000	DOE needs to look at what is being done in France and other places with the nuclear waste. It isn't fair for the waste to come to Nevada. Trying to decide whether to move my family from Nevada if Yucca Mountain is licensed.

425 01/04/2000 When is DOE going to listen that we don't want their dump?

Performance Assessment

Date **Comments**

05/01/1997

426 Commenters expressed general support for: the designation of Yucca Mountain as the location for the proposed repository, the need of a repository, the job the DOE was doing on characterizing the site, and/or nuclear power (some citing the need for a strong nuclear deterrent). Some comments included: Nevada needs to help solve the national environmental problem of nuclear waste disposal, the health risks are acceptable, the project will bring jobs and other technological benefits to Nevada and the State (or citizens) of Nevada should be specifically targeted for direct or indirect compensation, the environment surrounding Yucca Mountain has already been impacted by nuclear testing, the historical record indicates that the emergency response infrastructure would require only minor enhancements to handle the shipments, and the archaeological record and studies support deep geologic disposal. Other commenters felt that the project had been studied enough and DOE should move forward. One commenter encouraged DOE to use well-trained people in operation of the repository.

05/01/1997

427 Commenters expressed the need for the repository EIS to evaluate events and processes, including those having low-probabilities of occurrence, but resulting in high consequences. Others requested the analysis of credible events and processes, and worst case events and processes (regardless of probability).

428 Commenters requested that the EIS describe the seismic design and its basis, including a deterministic evaluation of maximum credible seismic events based on ground motion, as well as resulting secondary effects such as transient or long-term changes to the water table.

429 Commenters also requested deterministic evaluations of both direct and indirect effects on the repository from volcanic activity.

430 Design measures to mitigate the effects of events and processes (e.g., loss of water resources from contamination) were also requested. Events and processes identified by commenters included: (1) criticality (different kinds of events, multiple and repeated events, events resulting in explosions, events due to different fuel enrichments and plutonium disposal), (2) extreme seismic activity (resulting in pathways for contaminant release), (3) volcanism (volcanic explosions, consideration of "recent" events at Lathrop Wells cone), (4) tectonic events (crustal faulting), (5) meteorological events, (6) hydrological events, and (7) biological events.

05/01/1997

431... Commenters wanted the EIS to address the abilities of the waste packages to contain SNF and HLRW (for thousands of years, forever, until full decay has occurred, how long?) given thermal dissipation requirements, radioactive bombardment, photo disintegration, nuclide release rates, failure under earthquake-induced stress, and other natural hazards. A commenter requested that the EIS select manmade and natural materials that will retard the movement of radionuclides for placement in the near-field around the waste packages. These materials were requested to reduce uncertainties associated with the retardation potential of the host rock and to be consistent with DOE's suitability guidelines and the U.S. Nuclear Regulatory Commission's regulations, both of which call for "multi barrier" concepts. Another commenter requested that the EIS provide a description of engineered features that would provide adequate containment of C12 for 10,000 years, without reliance on natural barriers. One commenter requested a discussion of the measures that would

431 cont. ensure the integrity of repository seals, as well as any other barriers to permanently separate the waste from the environment.

05/01/1997 432 Commenters were concerned that the ability of the EIS to predict the long-term behaviors of the waste, their interactions with the natural and engineered barriers, and their ability to isolate waste would be insufficient. Others were concerned that insufficient data and information had been collected to predict behavior of the repository, and, accordingly, A assumptions should be presented in the EIS. 433 Still others requested the EIS to adopt "excessive conservatism" to compensate for the magnitude and broad range of uncertainties in projecting analyses of the future. 434 Others requested that the analyses consider gaseous pathways for radionuclide release, mineral deposits formed by thermal fluids, thermal overloading, thermal-induced ecosystem affects, thermal expansion and later subsidence, gaseous flux, groundwater heating, thermally induced fracturing affecting fluid flux, increased erosion due to ground surface denudation, local meteorological effects, the quality of the rock below the repository horizon, and radionuclide transport by mineral colloids. 435 In general, the EIS should estimate the "long-term cumulative impacts to the environment and therefore to humans." 436 Examples cited by other commenters were the potential for humans and the environment to be affected by transport of contaminated groundwater (Death Valley National Park, contamination of regional aquifer), and changes in the vadose zone from the high thermal load alternative. Some commenters questioned whether the EIS could provide information after failure of the waste packages such as mixing of various metals, minerals, isotopes, water, and heat. One commenter requested that a "maximum credible scenario" should be developed for releases from the repository.

05/01/1997 437 Commenters were concerned that the analyses in the EIS could not reliably predict future human behaviors and thus there could be no sound basis for predicting the probability of human intrusion; therefore, the EIS should assess the impacts of a full range of human intrusion scenarios, including accidental (e.g., because Yucca Mountain is in a "world class mining district") and intentional (e.g., because of potential value to future societies) breach of the repository.

05/01/1997 438 Commenters requested that the EIS consider the impacts of releases from the repository at the "population level." The EIS should report all dose response models and label each as to whether they are only fatal cancer models or include other health effects. Radon and other gaseous emissions via fracture pathways should also be evaluated. The long-term effects of heat on the ecosystem, and in turn how an altered ecosystem may effect waste isolation, should be analyzed in the EIS. Releases from the repository to the regional groundwater system (specifically Death Valley, Pahrump Valley aquifer, Ash Meadow area), based on a regional aquifer Characterization program, must be considered.

05/01/1997 439 Commenters expressed the need for the EIS to identify institutional controls (e.g., markers) that would endure for very long periods of time, particularly given the likelihood that government agencies and the English language may not survive that far into the future. Justification for this endurance, such as would be demonstrated by research on their effectiveness, was requested.

05/01/1997 440... Commenters requested that the post-closure environmental impacts be ascertained over the long-term, with long-term being defined by criteria "for the acceptable level of hazard." The time period selected for analysis by these criteria would then be presented in the EIS with a rationale for selection of various alternatives for analysis. Others suggested that the EIS

440 cont. identify the period for analysis based on how long the waste would remain lethal to humans. Examples of periods ranged from 1,000 to 1,000,000 years or until a peak dose is released.

05/01/1997

441 Commenters asked for the EIS to address site conditions and future societies that may be impacted; both should be projected at least several thousand years into the future given geological history, climatological conditions and global warming/cooling, and land uses. Site conditions mentioned included effects from perched water in the repository block, flooding, and changing water tables. Some commenters acknowledged that predicting societal change over the long-term was impossible; however, they also requested the development of a credible framework for assessing these long-term socioeconomic and health impacts.

05/01/1997

442 Commenters expressed a general opposition to Yucca Mountain (or Nevada in general) as a location for the proposed repository, repositories in general, and nuclear power. While some commenters provided no specific reasons for their opposition, reasons that were provided included: selection of the site was politically motivated, not scientifically motivated; Yucca Mountain is not suitable (perceived technical and safety problems); insufficient knowledge of the impacts of the repository; fear of the health effects of radioactivity; if there is no nuclear power, there will be no nuclear waste and no need for a repository; Nevada didn't create the waste so they shouldn't have to dispose of the waste; the people of Nevada have had more than their share of undesirable government projects (e.g., nuclear weapon testing at the NTS); there is no way to guarantee safety; fear that burying radioactive waste will make the earth uninhabitable; preference for solar power; fear that once SNF and HLW start coming to Nevada other types of waste will also be sent to Nevada for disposal; and the waste should not be buried, real solutions to the problem should be found. One commenter noted that they have been monitoring the Yucca Mountain Project (and other DOE activities) in the past and would continue to do so.

05/01/1997

443 Many commenters requested that DOE complete the Implementation Plan soon after closure of the scoping period, and that DOE provide a draft Implementation Plan for further review and comment by the public (both as a written document and from additional public meetings). Some commenters requested that the Implementation Plan provide a "comprehensive road map" describing how the EIS will support decision-making. Others requested that the implementation Plan provide a demonstration of the necessary methodology, scientific accuracy, and professional integrity needed to develop the EIS, possibly by involving the Council on Environmental Quality and/or independent peer review. One commenter noted that the Implementation Plan should discuss how DOE will address the inevitable changes in programmatic assumptions and parameters. One commenter suggested that DOE provide the comments from scoping to the affected state agencies, and another requested the comments be sent to DOE's Bartlesville Research Facility.

05/01/1997

444 Commenters criticized DOE on several issues, including; failure to establish a firm policy for SNF management after more than 50 years, forcing the repository program on the people. Several commenters criticized DOE for distributing a questionnaire {the questionnaire was actually distributed by project opponents and received extensive use by

445 the public}. One commenter hinted the DOE was not 46environmental conscious" by failing to use recycled paper products.

332

Planning

Date	Comments
05/01/1997 446	Two commenters discussed a 5-step process for solving the nuclear-waste issue: (1) impose a moratorium on all shipments of nuclear waste; (2) establish a commission on nuclear waste; (3) pursue conservation and renewable energy sources and phase out nuclear energy; (4) establish a national nuclear-waste policy that respects the sovereignty of states, counties, and tribes; and (5) pursue an aggressive policy of nuclear-weapons disarmament.

Public Participation

Date	Comments
02/25/1992	Also concerned with linking NNWTF public participation with NWRP so it can be more of a two-way street.
02/25/1992	Concerned that public participation needs to become a two-way street not just the NWRP providing info to the public. Thought the League of Women Voters might help with this process.
02/25/1992	Wanted the National Wildlife Commission added to the Attentive Publics Report on interested stakeholders.
02/25/1992	Public awareness of the County NWRP is low.
03/27/1992	Need to not limit stakeholders based on their predisposition to the repository. Add AARP because retired is an important Clark County constituency.
03/27/1992	DOE's history makes building trust difficult. DOE can't make long term commitments to short-term Congressional representatives. Repository should be isolated from political process.
06/18/1992	PRC thinks County should be the provider of "unbiased" information to the public
06/18/1992	Citizen input needs to be incorporate into socioeconomic studies according to the PRC
06/18/1992	PRC thinks that the context of risk communication is related to public perception of risk
12/23/1992	Early, regular, and timely public participation in SEAB Task Force doesn't happen. Meeting should be held in the local area. Lincoln County is wiling to be more involved in program planning than other state and local entities
10/07/1993	Concerned about the public's perception of the Steering Committee's decision making ability.
10/07/1993	African Americans in Favor of the Yucca Mountain Study. Represents the west side of Las Vegas where proposed transportation will impact an area with high unemployment and environmental racism. They want more focus on this area and greater participation.
11/15/1993	YMP Public Involvement Board has no public involved. Only gets public input at beginning of process not prior to. DOE needs to "work with the public" not "educate."

11/15/1993 DOE should not be "Gate Keeper of Information." Interest is either high or non-existent, not low as stated by DOE.

11/15/1993 Add public info in Spanish, sign, Braille and plain English. Use small groups.

11/15/1993 Plan is still top down, needs not just to get the rhetoric right, but actually integrate the public into planning.

11/18/1993 IAI's work plan should be amended to eliminate transportation, ER Management and GIS. Focus instead on Risk Perception and Risk Communication.

11/18/1993 Believes that current approach by state and local government does not adequately focus on community level impact.

02/09/1995 A monitoring program that tracks reactions at the individual and institutional level should be set up. Future survey work should be viewed as a monitoring tool. Analogs need to be mined. More detail on characteristics of organizations needed.

02/09/1995 NWD should consider ways of communicating results of socio-cultural studies to public.

07/26/1995 Concerned that public was not educated about how to respond to emergencies from low level or other wastes. The Steering Committee appears to be awaiting legislative definition of wastes before public education plans implemented.

04/11/1996 DOE should provide shipment notification procedures, estimates of materials and volumes
447 to be shipped, and designation of points of contact for corridor jurisdictions.

04/11/1996 Internet and hard copy annual reports to include identification of carriers, sources & destinations of each shipment, number and volume of shipments for each substance, routes,
448 incident/accidents and mitigative actions, evaluation of each shipment.

04/11/1996 Regular meetings between DOE and all interested stakeholders should be used to provide
449 updates on shipping campaigns; evaluation of past shipments; significant changes; and impacts or concerns of local communities from transportation of HLW.

05/01/1997 Some commenters felt that the NEPA process was costly; others felt the process only served
450 to provide environmental extremists a method to delay or halt important projects. Some commenters felt that the ultimate decision on the repository should be left up to a national vote.

05/01/1997 Commenters requested that DOE develop and implement a process that would maximize public involvement during finalization of the alternatives and preparation of the EIS and the
451 Record of Decision. DOE should also provide a means to inform and educate the public of the risks and consequences of developing the repository. This process could be facilitated by developing "citizen advisory boards around transport communities" or public citizen's action committees. Other commenters requested that DOE "seriously" consider all comments provided.

05/01/1997 Commenters said that the public and Native American Tribes had not been well informed about potential activities presented in several DOE EISs including: the Foreign Research
452... Reactor, Multi-Purpose Canister, Programmatic Spent Fuel Management and Idaho National Engineering Laboratories, Programmatic Waste Management, Nuclear Weapons

452 cont. Nonproliferation Policy, Transfer and Disposition of Surplus Highly Enriched Uranium, Fissile Materials, Uranium Supply and Recycling, and Stockpile Stewardship EISs.

05/01/1997 Commenters requested that DOE hold meetings in communities within all states and counties through which SNF and HLW will be transported, asserting that without which, the public's right to comment is compromised. Commenters also requested that additional scoping meetings be held in Nevada (e.g., Elko, Eureka, Ely, Amargosa Valley), in various other identified communities (e.g., Belen, New Mexico), and in affected Indian communities. Others expressed concern that Yucca Mountain Project scoping meetings were scheduled coincident with other Departmental meetings thereby minimizing public input into the scoping process. These commenters suggested that a formal policy be institutionalized requiring meetings to first be cleared with the hosting site. One commenter noted that scoping meetings should not be held on the Jewish Sabbath.

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05/01/1997 Commenters indicated that insufficient notice and inadequate information (no detailed maps, little information detail, poor description of proposed action) were received by communities and individuals located along potential transportation routes. Others suggested that DOE should: (1) contact every affected tribal government by means that will ensure receipt of information, (2) provide public service announcements on the front page of newspapers, (3) provide announcements to the television media, and (4) provide greater detail and information regarding the proposed action and aspects of transportation.

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05/01/1997 Commenters requested that the scoping process (i.e., meetings, written comments) be restructured to develop a broad-based public consensus process. Some commenters requested that: (1) the scoping period be extended (2 months), (2) the public participate in the identification of impacts, (3) they be allowed to provide pre- decisional input, and (4) the EIS include interviews with Nevada residents previously exposed to radiation. Other options to the scoping meeting format used by DOE were suggested that would allow for: (1) round-table panel discussions; (2) the formation of citizen advisory boards in reactor communities; (3) a shortened introduction, without the use of visual aids, by the DOE speaker; (4) the use of personal recording devices; (5) question and answer sessions exclusively; (6) no limitations on the number of speakers; (7) the elimination of "biased" materials presented by DOE, and improved answers to audience questions; and (8) relocating the microphone to enable speakers to address the audience. One commenter requested written acknowledgment that comments were received by DOE. Some commenters found that parking facilities were inadequate, that meeting rooms were difficult to locate. and that e-mail did not work properly, all of which act as a deterrent to public participation.

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05/01/1997 Several commenters requested that DOE hold public hearings on the draft EIS in their particular communities. Commenters also requested a 90-day public comment period on the draft EIS.

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05/01/1997 Commenters directed some of their comments to the public. Comments included: the NEPA process is the public's opportunity to voice opposition or support and the public is failing to take advantage of their opportunity to provide input into the NEPA process. Commenters noted poor attendance at the scoping meetings and indicated the public asked questions and provided comments on unrelated subjects. Other comments offered advice on sources of public information.

Regulatory Standards

Date		Comments
No Date		Concerned that HR 1020 and HR 1924 reduces environmental standards required.
10/08/1992		Section 801 of the National Security Act amends NWPA to relax radiation standards.
10/08/1992		Yucca may not meet Carbon-14 standards under new radiation standards
10/08/1992		Standards lowered and Energy Committee is being overly influenced by nuclear industry
09/27/1995	457	NAS concludes that EPA standards on institutional controls and whether engineered and geologic barriers can avoid be breached for 10,000 years can't be proven.
05/01/1997	458	Several commenters requested that the EIS discuss the Constitutional basis for a federal agency to: (1) take title to nuclear waste generated by private industry, (2) commandeer the natural and governmental resources of the State of Nevada, and (3) affect Nevada's socioeconomic well-being. In addition, commenters wanted the EIS to: justify the selection of Yucca Mountain against the wishes of the State of Nevada; discuss how the DOE intends to acquire exclusive jurisdiction of the Yucca Mountain site considering the Constitutional requirement that exclusive jurisdiction can be acquired only in the manner set forth in Article 1, Section 8, Clause 17, of the U.S. Constitution; and discuss how the DOE will acquire the required consent of the Nevada Legislature for exclusive jurisdiction of this land.
05/01/1997	459	A few commenters indicated a variety of concerns relevant to the analyses in the EIS, citing the failures by Environmental Protection Agency to set rigorous radiation-release standards based on Section 801 of the 1982 Energy Policy Act, and the failure to faithfully apply the scientific method, because Yucca Mountain would have been disqualified.
05/01/1997	460	A commenter questioned the use of the release standards, noting that assurance of long-term isolation of radionuclides from the human environment is not achievable, because existing and proposed radiation-release standards allow for some radiation to escape from the repository.

Schedule and Licensing

Date		Comments
05/01/1997		One commenter asked whether the DOE's schedule for submitting a license application to the Nuclear Regulatory Commission in 2001 (as described in the DOE's program approach) is the reason for holding EIS scoping hearings in 1995.
05/01/1997	461	Commenters were concerned that the EIS would be based on preliminary information with high uncertainties (site characterization incomplete, reliance on computer modeling), and on preliminary test results (thermal-load testing not mature).
05/01/1997	462...	Several commenters said the EIS should focus on the technical aspects of site suitability and the license to operate the repository (e.g., demonstrate that the proposed action and alternatives meet the licensing criteria in 10 CFR 960, collect EIS data pursuant to quality assurance criteria similar to those used for licensing). Some commenters were concerned

462 cont. that the 5-year schedule for the EIS was too short considering its relationship to site suitability and licensing, whereas other commenters believed that the schedule was too long.

05/01/1997 463 Four commenters were concerned about the schedule for opening a repository at Yucca Mountain. Three noted that DOE has a responsibility to start accepting waste shipments at the repository in 1998, but that 2010 is now the best that can be done. The other requested that the amount of time between scoping and licensing be explained.

Socio-Economics

Date	Comments
02/25/1992	Wanted the National Wildlife Commission added to the Attentive Publics Report on interested stakeholders.
03/26/1992	Stated that DOE is threatening lay-offs at WIPP to pressure New Mexico into cooperating
03/26/1992	Stated that TRW wants to work with NWRP
03/26/1992	Argued that TRW and NWRP should work together on socio-economic impacts to avoid duplication.
03/27/1992	UNLV's REMI Model only supplies short-term forecasts. Discussion of what is the appropriate time horizon that should be evaluated. REMI is too detailed and not useful for the long term analysis that is needed
03/27/1992	Length of residence not type of housing stock is the criteria for measuring impacts. Mobile homes denote a transience that is not accurate at least in Indian Springs.
06/18/1992	According to the PRC, the planning approach is ambitious, should be phased in so that it can be sustained by local government if DOE funding is cut.
06/18/1992	UNLV's REMI Model only supplies short-term forecasts. Discussion of what is the appropriate time horizon that should be evaluated. REMI is too detailed and not useful for the long term analysis that is needed
06/18/1992	Stated PRC thought that the Draft Research Design should include social and risk issues not just economic.
06/11/1993	PRC fins socio-cultural work lacking ethnographic interviews and documentation of repository related events.
10/07/1993	The licensing support system advisory board has selected DOE to manage all licensing information. No socio-economics will be considered for licensing.
02/09/1995	Agrees with PRC on needs but funding limits response. Should be more of a focus in 1996.
02/09/1995	Although socio-cultural research has a good start, studies should continue utilizing a range of external and internal expertise. County needs to monitor the nature, duration, and intensity of constituent views.

464	12/21/1995	37% of Yucca Mountain employees live in 4 zip codes in the most rapidly growing areas in Las Vegas. This is accelerating the rate of expansion of needed services.
465	12/21/1995	Gaming, sales, and room taxes are critical to the local economy and could be damaged by the repository.
466	12/21/1995	Local government funding may fall short of what is needed to provide services to the impacted populations.
467	12/21/1995	Accidents associated with HLW can be amplified by the media and negatively impact tourism.
468	12/21/1995	The HLW program may cause political conflict between various local government and economic development entities.
469	12/21/1995	Tourism currently underwrites many of the services provided to DOE employees.
470	12/21/1995	Based on ruling in Santa Fe versus Komis local government may be liable for perceived impacts on property values. A baseline on property values are needed.
471	12/21/1995	Concerned that nuclear waste transport and resulting amplified perception of risk will negatively impact property values.
472	03/20/1996	The analysis of socio-economic impacts should be broadened. It should cover transportation impacts, boom/bust potential, and the effect of controversial projects on large social systems.
	05/03/1996	Direct, indirect, and induced impacts must be considered in the NT EIS.
474	05/03/1996	Expansion of use of NTS will result in additional ER costs for county and local gov't. This should be included in EIS and paid for by DOE.
475	05/01/1997	Commenters believed that the EIS should analyze the various options for implementing Section 180(c) assistance per the NWPA.
476	05/01/1997	Three commenters stated that the EIS should use socio-economic models that consider local projections and not rely on national or regional projections. The models should consider economic and population growth driven by retirement and "lifestyle" migration, and should operate at a sub-county level. All assumptions used in the analysis should be made explicit and justified by reference to social science theory and/or experience in analogous cases. And, the methods by which impacts are estimated should be specified so that they can be reviewed and validated. Conclusions and findings should account for the applicable data and present the logic for any professional judgments, including specification of probabilities and ranges of uncertainty when appropriate. Conditions for which there are insufficient data or theory to make a finding should be identified, the current level of knowledge should be explained, and the implications for drawing conclusions should be presented. The EIS should then make recommendations for resolving significant issues that cannot be properly evaluated due to data or theory limitations.
477	05/01/1997	Two commenters suggested that the EIS consider the management of nuclear waste at Yucca Mountain by future generations.
478...	05/01/1997	Several commenters requested that the EIS clarify the extent and longevity of responsibility and liability for impacts associated with the disposal of nuclear waste, and for accidents

478 cont. along transport routes from points of origin to Yucca Mountain. Another requested the name of all elected and appointed individuals that have responsibilities and liabilities with regard to the Yucca Mountain Project, as well as agencies involved in the decision-making process.

05/01/1997

479 Commenters stated that the EIS analysis of potential socioeconomic impacts should be evaluated against a baseline affected environment. Some commenters viewed the baseline as existing without Yucca Mountain site characterization activities. Commenters provided detailed lists of parameters to be described in the baseline, including: economic (employment and income by SIC sector), demographic, social, and public finance conditions (including growth trends); conditions in the State of Nevada, southern Nevada counties and sub-county jurisdictions, communities, and impact areas (including government structures and finances, military operations, telecommunication capabilities, community services, emergency management, public health, land use, and transportation infrastructure and traffic); economic base in the State of Nevada, southern Nevada counties, and key sub-county communities - key interregional linkages for each major component of the economic base at each of the above levels; current demographic and social character, public perceptions, and political landscape; local government service systems and expenditures at each of the above levels (including state- .shared revenues); Nevada's state/local revenue structure, and the revenues generated for public funds at each of the above levels; and community social conditions. One commenter suggested the EIS should attempt to incorporate the trend toward increased per capita local government service costs.

05/01/1997

480 Several commenters suggested that the EIS incorporate data and information available from potentially affected counties and communities within the state of Nevada. The range of data and information cited by these commenters include, but is not limited to, databases on geotechnical features, socioeconomic conditions, geographic information system capabilities, emergency preparedness inventory and analysis, rail corridor route analyses, infrastructure damage assessments, regional hydrology studies, ethnographic studies, and rest area needs and impact analysis.

05/01/1997

481 Commenters requested that the Implementation Plan provide a description of the contents of the Record of Decision. Commenters also requested that the Record of Decision include: (1) how, and by whom, costs for emergency preparedness and response along transportation routes will be paid; (2) mitigation measures that were adopted to avoid or minimize impacts, rectify concerns or conflicts, and compensate affected parties for unavoidable consequences; (3) mitigation measures that were not adopted and the reasons why; (4) the basis for the decision, and (5) an explanation of alternatives considered and the identification of the environmentally preferable alternative.

05/01/1997

482... Commenters indicated that the EIS analysis of potential socioeconomic impacts should examine impacts during construction (including necessary nationwide transportation infrastructure improvements), operation, closure, and post-closure of the repository (one commenter requested the analysis also be applied to impacts for recent layoffs from the Yucca Mountain Site Characterization Project). They recommended that the analysis include impacts under routine operations and following accidents. Analyses should include potential impacts to: employment, wages, income, population growth, procurement, limited infrastructures (including transportation and traffic), tourism, population growth (negative impacts not related to project employment), schools, business, insurance recovery, property values, local government finances and fiscal conditions, health care costs, loss of economic potential associated with the withdrawal of land for the repository, transportation corridors

482 cont. and any buffer zones, and local politics and intergovernmental relations. One commenter suggested the EIS should assess the technological assets the project might bring to Nevada including projections of supporting science and techno/scientific spin-off development. Others thought the EIS should consider the social impact from the repository project, which may increase public dissatisfaction with their government or alter community cooperation and/or conflict. One commenter suggested the EIS, in evaluating these impacts, should consider multiple construction scenarios, for example construction by a single crew or multiple crews.

05/01/1997 Commenters said that the EIS should include a detailed description of all affected environments and impacts to those environments. More specifically, the analyses should
483 include: (1) worst-case and mile-by-mile assessments of potential impacts along transportation routes and the emergency-response measures along these routes; (2) the effects of the environment on the safety of waste shipments, including a discussion of the controversial nature of waste transport; (3) retrievability of the waste, along with the disposition of the retrieved waste; (4) the economic, social, health, and psychological costs of transporting and storing the waste, including the costs of accidents; (5) negative effects on property values, businesses, and tourism near the site and along transportation routes;
484 and (6) risk, risk perception, and stigmatization. One commenter requested that the EIS discuss the ethics of no action, including the eventual shutdown of the nuclear industry, increased consumption of fossil fuels, impacts to the U.S. economy from diminished
486 supplies of electricity, and State rights versus the good of the nation. Other commenters 485
said Yucca Mountain should be discussed as a national sacrifice zone, the EIS should not be
488 schedule driven, assumptions concerning expected levels of program funding should be 487
489 discussed, and the EIS must assess all subjects mentioned in Title V of the NWPA.

05/01/1997 During preparation of the socioeconomic impacts analysis, commenters suggested that DOE
490 work closely with county and tribal governments to consider the views of these organizations. In addition. commenters emphasized that DOE should utilize data, evaluation models, and studies prepared by counties in their analyses.

05/01/1997 Commenters believed that the socioeconomic analysis should be conducted at a level which
491 reveals rather than obscures potential impacts, and which supports evaluation at the community level. Key dimensions included: annual estimates of transportation shipments, employment, and procurement effects, analysis at community-specific geographic levels (worksite locations, community ZIP code, place of residence, or procurement destination of payment), and shipments by Nevada transportation route segment; cause and effect links between expenditure, management policy, work activity, and estimated Nevada employment and procurement; cause and effect links between the current and projected inventory, the acceptance schedule, and the characteristics of shipment campaigns; cause and effect links between projected shipments, surface facility capacities, and permanent disposal capacity. One commenter suggested the EIS should discuss socioeconomic impacts in cause and effect terms to allow reviewers to understand and trace the estimation of potential impacts.

05/01/1997 One commenter believed that the EIS, in reaching a decision for selection of transportation
492 routes, should consider the potential socio-economic impacts.

05/01/1997 Several commenters believed that the EIS should discuss possible mitigations to offset or
493.. compensate negative socio-economic impacts and provide analysis of how the measures would offset impacts. Suggested methods to mitigate impacts included use of Department policies that would encourage project employees to reside in specific counties, use of union

493 cont. versus non-union labor, or procurements being awarded to local companies. Some commenters requested this discussion should provide all sources of compensation for the diminution of property values caused by property being located in proximity to transportation routes and sources of compensation for takings of business opportunities and property interests which may be caused by perception-based impacts. One commenter stated the EIS should address how the program will achieve acceptable equity and fairness standards for the key affected communities, states, and participants. This analysis should consider acceptance in terms of a burden placed upon state and local governments and citizens.

05/01/1997
494 A commenter recommended that the EIS discuss uncertainties and potential changes within the Yucca Mountain Project and the Civilian Radioactive Waste Program that may be affected by funding adequacy and socioeconomic impacts.

05/01/1997
495 Many commenters indicated that the EIS and resulting Record of Decision should commit DOE to providing compensation for those communities and individuals negatively impacted (people nearby an accident, those contracting cancer). Commenters specifically indicated that compensation should be provided for: project oversight by Native Americans (all tribes, not just the National Congress of American Indians), State of Nevada and affected counties; peoples suffering radiological exposure above guidelines preparation of transportation (section 180(c) of the NWPA), including accidents, education, emergency response, medical training and monitoring to communities along transportation routes; potential disruptions (routine, accidents, sabotage) and environmental damage from the construction and operation of rail spurs (Eureka County); health effects, floodplain damage, loss of game habitat/protected species, wetlands, disruption of crop production/marketing/transportation access, disruption of grazing patterns/marketing potential/mining and transportation access, and disruptions to historical rural and agricultural lifestyles; public safety training in local communities, especially affected governments and along highway or Tail routes; Clark and Nye counties; infrastructure improvements and maintenance; communities and states that are burdened with HLW facilities; police and fire protection, the cost of health/accident/disease prevention programs, and participation in worker safety programs.

05/01/1997
496 The EIS should provide estimates of the total life-cycle cost under each alternative (including No- Action and if Yucca Mountain becomes unacceptable). Cost should be a factor in the decision making process. The EIS should analyze cost impacts on a nationwide scope, not just the cost impacts at Yucca Mountain. Costs should be provided for all studies associated with site characterization; construction, operation, and closure of the repository; transportation; and post-closure. Costs associated with both routine and accident scenarios should be discussed. For accident scenarios the EIS should discuss financial responsibilities- An accident occurs at a utility, who pays for the clean up? During transportation, who pays? During operation of the repository, who pays? During post-closure, who pays? The EIS should include an analysis of costs associated with health impacts (sterilating miscarriage [sic], cancer, etc.), losses of tourism and business (including farming commodities value), loss of property value, loss of environmental opportunities because funding that has to be spent on the repository program will not be available to fund other environmental projects, and lack of distributed capital available to local economies. The analysis also should discuss factors that might influence the accuracy of cost estimates.

05/01/1997

497 Commenters stated that the EIS analyses of potential socioeconomic impacts should be conducted on specific populations, including Yucca Mountain area populations (unincorporated areas, cities and towns, counties, and Native American Reservations in proximity to Yucca Mountain), the State of Nevada, all areas affected by regional and national transportation of waste to the repository, and areas where waste might be stored. Other commenters preferred that the analyses be conducted at the community or neighborhood level, or by rural/suburban/urban areas. Commenters also recommended that the EIS provide a detailed evaluation of direct and indirect impacts on public services, state and local services, and state governments that occur as a result of the project, whether as fees, taxes, or other payments. The services to be assessed include all state and local government services that contribute to the program, and state and local public services to the direct, indirect, and induced population and households resulting from the program. The estimates of costs for these services should include expenses for all services, facilities, equipment, infrastructure, and staff. Revenues should be calculated for the project and these revenues should be compared to the costs of services. Services by jurisdiction and type of service should be analyzed and the analysis should be allocated to the proper jurisdictions consistent with the state and local fiscal structure. Lastly, commenters called for the EIS to estimate those impacts that are due to intergovernmental conflict, including costs of legal adjudication, law enforcement and criminal justice services, political activities, and restrictions on state/local/federal relations.

05/01/1997

498 Commenters stated that the EIS should evaluate credible accidents. Some commenters offered specific accidents for analysis. Specific concerns expressed by commenters were: terrorist attacks or sabotage; contamination and cleanup; evacuation; impacts on tourism; compensation; and radiation exposure.

05/01/1997

Commenters commented on actions and projects unrelated to Yucca Mountain. Examples included comments on: the Ward Valley Nuclear Waste Site in California, Senate and Congressional bills related to interim storage (opposition to the establishment of an interim storage facility in Nevada), the NTS Sitewide EIS, the Programmatic EIS for Storage and Disposition of Weapons-Usable Fissile Materials, operation of the NTS (general management perspective), the need for alternative energy sources such as solar power and hydrogen-powered fuel cells, the need for energy conservation, federal land control in Nevada, monitored retrievable storage in New Mexico, and financial rewards to persons that find practical solutions to continued use of radioactive materials. One commenter offered a marriage proposal to the Secretary of Energy, Hazel O'Leary.

05/01/1997

499 Commenters requested the EIS to present sufficiently detailed descriptions, for each alternative, in terms useful for socio-economic analysis and comparison between alternatives. The descriptions should include detailed data on: annual expenditures, employment, and procurement; annual waste and material transportation shipments; management policies (busing, housing, per diem, food service, etc.); and any community development programs or intergovernmental agreements for the provision of service to project.

05/01/1997

500 One commenter stated that the EIS should evaluate the feasibility of taxing each shipment of SNF or HLW at the county or state level.

12/17/1997

501 Impact assessment approach be DOE is too limited. Needs to measure the effect of public perception of risk on tourist economy; disproportionate impacts on minorities; increased costs on county and local government from increased service demand.

12/17/1997	Cumulative impacts are not being adequately measured.
502 01/04/2000	The State of Nevada and Clark County should negotiate a contract to accept the waste at the border in exchange for funding for a technology center at UNLV and UNR and money for elementary to HS education.
503	

Storage

Date	Comments
03/26/1992	Noted that Minnesota Public Utilities is considering blocking Prairie Island's request for dry cask storage that could be used beyond 1998.
05/01/1997 504	One commenter stated that the companies that build and operate nuclear power plants should be responsible for waste disposal.
05/01/1997 505	Commenters suggested that the Yucca Mountain project should be canceled and that the waste should be stored at the point of generation, some "voted" for DOE to adopt the No-Action alternative which would leave the waste at the generators. These comments were not supportive of DOE evaluating a No-Action alternative, rather, they advocated making the decision in absence of analysis. Reasons for this suggestion were not always provided; however, some reasons included: generator storage would be less costly, storage at generators decentralizes the risk of terrorist attack, opposition to transportation because of the potential risks involved in transportation, the generators reaped the benefit from nuclear power (or defense activities) so they should suffer the potential consequences, and no-action would be safer.
05/01/1997 506	Two commenters stated that the waste should be retrievable in the future, because it may be valuable and because future technological advances may solve the disposal problem.
05/01/1997 507	Commenters suggested that the EIS be deferred until funding issues are resolved, new legislation and standards are approved, and a revised program approach is developed. More specifically, the EIS should consider: (1) how the EIS process and assessment of impacts would be affected because of unfunded or underfunded state and county(ies) activities, (2) alternative funding mechanisms if the Nuclear Waste Trust Fund is depleted, and (3) how the EIS process will respond to legislation requiring siting an interim storage facility, and allowing DOE discretion in route selection and shipping schedules. In addition, these commenters recommended that, until these issues are resolved, DOE should plan on additional scoping meetings or scoping should remain open indefinitely. Commenters also indicated that the resulting implementation plan would be inadequate until these program issues are resolved.
05/01/1997 508	Commenters requested that the EIS discuss whether, when, and under what conditions the DOE would recommend that Yucca Mountain is an unsuitable site for a repository. One wanted an alternative plan if Yucca Mountain is found to be unsuitable.
05/01/1997 509...	Commenters requested that alternatives to geologic disposal be evaluated in the EIS. Suggested alternatives included interim storage (at Yucca Mountain or unspecified locations), reprocessing, seabed disposal, space disposal, waste treatment (e.g., annihilation reduction, brown gas, modular helium reactor use), and long-term temporary storage until treatment technologies could be developed. Several commenters suggested that alternative

509 cont. sites (e.g., Canada) be considered in the EIS. Others requested additional actions by DOE beyond preparing a Repository EIS (e.g., prepare separate transportation EISs and establish independent commission to review entire waste management and SNF program).

Transportation

Date	Comments
No Date	Choice of rail spur route whether through Caliente or Crestline is not clear; nor is funding which is subject to Congress. This means either truck shipments or USAF approval of spur though Nellis AFB at cost of $590 million or around it at $1.2 Billion.
No Date	DOE's must address perceived risk within Clark County, especially as it related to impacts on the gaming industry.
No Date	Illustrates that Craig Road in NLV which is used for LLW transport and proposed for HLW has grown from 2 to 4 lanes, traffic volume up 124%, 169% increase in # of developed parcels, and 24% increase in land value from 1988-94.
No Date	Intermodal cargo shipping provided 19,000 jobs in 1994. Disruption of traffic on I-15 and /or UP railroad could negatively impact this sector of the economy.
No Date	Average daily traffic is up 60% between 1983-1993 between Reno and Las Vegas along US 95. This corridor is growing rapidly and could be negatively impacted by the repository.
No Date	Clark County is concerned about the process for selecting routes in Nevada Test Site EIS. Although, this is for LLW, it has implications for HLW.
No Date	Opposes the rail spur alignment through the Las Vegas valley as proposed in HR 1020 and Senate bill S.167.
03/27/1992	TRANSPLAN and RADTRAN requires maintenance of a large database that historically has not been retained.
04/17/1993	DOE's transportation plans are interconnected with other socio-economic impacts and they are uncertain. This requires coordination.
04/17/1993	Local issues need to be incorporated into transportation planning by DOE and the State. Transportation alternatives should be at a site specific basis for use in accident forecasting not just at a segment level. Early involvement in State planning
04/17/1993	State should begin planning for alternative emergency routing. Rail routing alternatives need to be evaluated
04/17/1993	HazMat flows are needed for entire area done by one contractor using NDOT's at a collection format
06/25/1993	Prioritizes local government's planning concerns for nuclear waste transport (in descending order: Accident Analysis; HazMat Flows; Critical Infrastructure; Optimal Transportation Systems; Rail Routing; Alternate Routing

07/01/1993 18 high accident locations in Clark County identified (9 on I-15; 7 on SR 180.US 95; Ranch Road/Cheyenne Avenue; Jean to Sloan/rural area).

10/07/1993 Opposed to Hoover Dam route

10/28/1993 City of North Las Vegas needs more detailed transportation routing information and analysis of the TranPlan model.

02/09/1995 Transportation and ER management programs need to be better integrated through joint planning of research priorities.

510 02/09/1995 NWD staff respond that judgment of risk, perceived risk and prediction of behavior especially migration, and economic development impacts are increasingly a priority

511 02/09/1995 It is important to consider transportation links to risk perception along transportation corridors and the distance of vulnerable facilities to transport routes.

512 07/26/1995 Commented that most or all of highway HLW shipments will go through Indian Springs and local government is concerned about employment impacts.

07/26/1995 Indian Springs local government is concerned about the public safety aspects of HLW transport through their community.

513 07/26/1995 In response to a citizen concern indicated that training ER Management staff; educating and training the public; and developing systems for monitoring transportation are top priorities.

07/26/1995 Indian Springs TAB will provide a list of concern to Clark County on transportation issues.

09/27/1995 Testimony to House Committee on Commerce, Subcommittee on Energy and Power regarding HR 1020 (NWPA 1995) & HR 1924 (Interim Waste Storage Act concerned about proposal to construct rail line in NLV.

515 09/27/1995 DOE's Developing the Transportation Plan is now in EIS and has no focus on security (I.e. guards) for shipments.

516 11/22/1995 Collateral Risk is sum of risks posed by activities effecting shipment. Example, 8% of County roads undergoing construction at any one time. Accidents go up significantly around construction. Some routes have high frequency of construction must include.

517 11/22/1995 Transportation risk assessment methodology biased toward shortest path not optimal path. DOE needs to incorporate calculated risk, collateral risk, contectural risk, and perceived risk not just use probabilistic risk analysis (PRA).

518 11/22/1995 Impacts. EIS should address potential liability of local gov't to citizen suits related to transportation routes for HLW decreasing property values. Ex. WIPP lawsuit success.

519 11/22/1995 Perceived Risk cannot be calculated by usual modeling procedures. Must address actual or projected behavioral consequences. Example, route avoidance, avoidance of tourist area, reduction in business along route, actions to evade a HLW shipment.

520 11/22/1995 DOE's approach to risk assessment is limited to PRA. Should include Calculated Risk, Collateral Risk, Contextual Risk, and Perceived Risk. Suggested starting point 1993 draft Identification of Factors for Selecting Modes and Routes for Shipping HLW & SNF.

521	11/22/1995	Calculated risk (i.e. PRA) needs to be broader in scope and cumulative like RADTRANS.
522	11/22/1995	Contextual Risk results from unanticipated changes in risk environment. Example, an incident that delays movement of vehicle carrying HLW increases risk to public/workers. Assessments should incorporate realistic public safety capabilities.
523	11/22/1995	EIS must use MPC as basis not present generation casks. This will significantly change impacts since most HLW will go by rail with few alternatives. Rail accident data is unreliable.
524	12/21/1995	Traffic volumes and shipments of hazardous wastes have increased dramatically since 1980. If trucks are used 44 accidents are likely from transport of HLW to the repository. Even if minor, this could hurt economically.
525	12/21/1995	A serious accident with HLW combined with limited alternate routes and limited ER capability could shut down commerce and damage economy.
526	12/21/1995	The UP mainline is the major link between So. CA & Midwest. Freight transport was 8.7 Million in 1994 up from 6 million in 1990. 80% through trafiic,15% off-loaded & 5% on-loaded. This could be hurt by the repository.
527	12/21/1995	Even incident free transport may expose workers and motorists to radiation. Incidents even without releases are likely to amplify public concern. These will result in a negative impact on local economy and local government perception of capability.
528	12/21/1995	County may not be able to provide for emergency response because of timing and limits of funds due to federal policy and procedures.
529	12/27/1995	Concerned that the current DOE Draft Waste Management PEIS concludes that least risk is over Hoover Dam, US HWY 93/95, and I-15/95 interchange because methodology based on shortest path/shortest time this neutralizes risk concerns.
530	04/11/1996	DOE and stakeholders should agree on route selection methodology and it should be in ROD. DOE should provide route & risk analysis for each carrier transporting Class 7 wastes to local jurisdictions.
	04/11/1996	HLW loads should be covered to prevent aerosol disbursement. LLW loads arriving during off-hours should be parked in secured area inside NTS gates. Trucks carrying Class 7 waste should have 2 drivers.
531	04/11/1996	Carriers should respond to all driver advisories and notification of delays and adjust routes accordingly. All vehicles should be inspected quarterly and display appropriate safety inspection stickers.
532	04/11/1996	DOE should avoid the use of certain routes, segments of routes and shipping at specific times. Example, use of Spaghetti Bowl/Hoover Dam should not be allowed nor peak travel time transit.
533	04/11/1996	DOE should work with the State and corridor jurisdictions to develop criteria for the selection of safe parking areas to be used by carrier vehicles.
534	04/11/1996	DOE should require carriers to use selected primary routes except when they are responding to an official advisory or notification of delay.

535	05/03/1996	Effects on property values along transportation corridor must be assessed in DEIS.
	05/03/1996	The NTS EIS must include the methodology for selection of highway routes.
	05/03/1996	8 out of 10 shipments through densely populated areas of Clark County. Only 1 of 10 avoids metropolitan area and goes through rural area. Primary route identified is through the Spaghetti Bowl.
536	05/03/1996	Clark County is in early stages of 10 year transportation improvement project. This results in increased accident risk this must be considered.
537	05/03/1996	DOE's route selection methodology should incorporate criteria in addition to time & distance. Carriers should be bound to the selected routes with the exception of official notification of delays.
538	05/01/1997	Commenters stated that the EIS should select and evaluate rail and heavy haul routes, offering criteria for selection such as: public concerns; engineering feasibility; impacts of construction and operations; baseline environmental data; cost; rights of way; Native American claims and cultural resources; public health; case of access; fairness; potential for shared use; grade crossings; infrastructure and track condition; land use; rail construction standards; locations of maintenance and operations facilities, and material source sites; coordination between agencies; ownership and operator issues and anticipated likely use by mode (including dedicated trains).
539	05/01/1997	Commenters requested that other/additional transportation routes or alternative modes be evaluated in the EIS: (1) regional corridors through Nellis Range and Goldfield vicinity, (2) other modes (e.g., aircraft, rapid transport/dedicated rail), (3) other mixes of national truck and rail modes (e.g., 50:50, 60:40), and (4) limited use of truck shipments.
540	05/01/1997	Two commenters asked if the public would be aware of the import locations of military waste bound for the repository.
541	05/01/1997	Commenters asked questions about the methods or data to be used in the transportation assessments in the EIS, The use of "comprehensive risk assessment" was advocated by some commenters. Other commenters advocated a comprehensive systems analysis or a traffic impact analysis. Commenters also stated that the EIS should rely upon previously published studies when possible.
542	05/01/1997	Commenters expressed a general opposition to transport of SNF, HLW, or radioactive material in general. Comments supporting this opposition included: railroads are unsafe, fear of exposure to radioactivity, fear of accidents, dangers can not be 100% eliminated, and railroads would prohibit access to lands. Some commenters suggested that the public and state governments should, and will, protest transportation by blocking highways and railways.
543	05/01/1997	Commenters requested that additional packaging options be described and evaluated in the EIS. Additional options included: (1) different materials to construct waste packages, (2) legal-weight truck Multi-Purpose Canisters, and (3) different package designs. One commenter wanted the description of the packaging options to indicate that As Low As Reasonably Achievable principles would allow some radiation to be emitted from packages.
544...	05/01/1997	Commenters were generally concerned about shipping containers or casks. Specific comments/concern that should be addressed by the EIS were: safety and integrity of

544 cont.		containers; deterioration; use of multi-purpose casks; cask construction and testing; lack of containers; heat of the SNF inside the cask..
545	05/01/1997	Commenters stated that the EIS should focus on transport-only casks, not on multipurpose casks. Other commenters stated that the EIS should focus on the 75-ton multipurpose cask, not on the 125-ton multi- purpose cask.
546	05/01/1997	Commenters stated that full scale cask testing should be performed on the casks analyzed in the EIS. Other commenters stated that full scale cask testing was not necessary.
547	05/01/1997	Commenters stated that the EIS should describe the shipping containers or casks to be used for SNF and HLW, The EIS also should discuss which fuels will be transported by which containers.
548	05/01/1997	A commenter stated that the number of shipments used for the impacts analysis should be estimated based on single assembly casks, in order to provide an upper bound on the number of shipments.
549	05/01/1997	Commenters stated that the EIS should consider emergency response capabilities, training, and needs. Other commenters stated that emergency response problems unique to rural areas should be addressed in the EIS. Other commenters had questions about emergency response plans and responsibilities. Commenters also stated that the EIS should evaluate large-scale evacuations.
550	05/01/1997	Commenters had concerns about the implementation of Section 180(c) of the NWPA. Specific concerns included: funding; schedule; policy; ongoing training.
551	05/01/1997	Commenters were generally concerned that the EIS address various aspects of transportation, such as: cost; pre-notification requirements; insurance; comprehensive analysis of impacts; credible scenarios and alternatives; environmental effects; effects on infrastructure; planning; cask testing; safety; security; emergency response; routing; historical and future shipments; impacts on Native Americans; compliance with regulations and identification of assumptions.
552	05/01/1997	Commenters were generally concerned about transportation accidents or exposures- that the risks from transportation would be low.
553	05/01/1997	Commenters stated that some areas may be exposed to greater levels of risk than comparable areas in the U.S. and these increased risks should be accounted for in the EIS.
554	05/01/1997	Commenters stated that radiological and non-radiological impacts from transporting SNF and HLW should be evaluated in the ETS, for both workers and members of the public (including people along the route and people sharing the route). Cumulative health impacts and shipment of multi-purpose canisters also should be evaluated.
555	05/01/1997	Commenters stated that they were concerned about transportation accidents, while others were not concerned about transportation accidents. One commenter requested that the EIS update the data base used for the analyses.
556	05/01/1997	Commenters stated that the EIS should consider U.S. Nuclear Regulatory Commission requirements for shipping containers in the transportation accident analyses in the EIS.

557 05/01/1997 Commenters stated that the impacts from sabotage or terrorist attacks should be evaluated in the EIS.

558 05/01/1997 Commenters stated that a full range of transportation accidents, especially low probability/high consequence accidents should be evaluated in the EIS. Other commenters stated that the EIS should evaluate a severe, but credible, transportation accident. Some commenters offered specific transportation accidents for analysis.

559 05/01/1997 Commenters stated that the EIS should evaluate the impacts to groundwater and surface
560 water, and to game habitat and protected species from potential transportation accidents.

561 05/01/1997 Many commenters were generally concerned about transportation. Specific comments/concerns relevant to the EIS included: areas in their communities to be avoided; advance notification of shipments; local control of routing and time of day restrictions; avoiding their community; providing impact analyses for their community; presence of Native American populations along routes; objections to truck or bad routes and property values along routes.

562 05/01/1997 Commenters stated that options for transport modes, rail service, or heavy haul roadways should be evaluated in the EIS.

563 05/01/1997 Commenters stated that impacts should be presented for areas and along routes where many shipments occur, and that for each, the total population at risk, the potential radiation doses, health impacts, or the number of shipments should be presented in the EIS.

564 05/01/1997 Commenters stated that a route-specific or mile-by-mile assessment of transportation routes and impacts should be performed. Areas to be addressed in the assessment should include radiation doses, accident risks and consequences, emergency response, emergency preparedness, mitigation, and infrastructure. Other commenters stated that a mile-by- mile assessment was not necessary.

565 05/01/1997 Commenters stated that the EIS should evaluate the economic impacts of transportation accidents.

566 05/01/1997 Commenters stated that typical or probable transportation routes should be presented in the EIS.

567 05/01/1997 Some commenters suggested specific rail or heavy haul routes or intermodal transfer stations, which should or should not be considered by the EIS.

568 05/01/1997 Commenters stated that the statutory authority for routing and the responsibilities of each level of government be identified in the EIS. Further, potential state designated routes or alternative routes should be considered in the EIS, as well as U.S. Department of Transportation routes (considering exposure risks and local economic benefit). Other commenters requested that the DOE develop a routing policy (based on factors such as emergency response, population, accident rates, weather, seasonal road closures, and infrastructure), and some stated that the carriers not be allowed to select routes unilaterally.

569 10/16/1997 HLW shipments could negatively impact visitor economy and area business climate.

570 10/16/1997 Property values along transportation corridor may be lowered.

571	10/16/1997	HLW shipment impacts include added radiological risk to residents and visitors because of routine shipments and potential accidents.
572	10/16/1997	County will have to add services designed to monitor DOE and protect public health and the environment.
573	12/17/1997	Privatization of transportation to repository does not appear to be cost effective and may interfere with established DOE and local government interactions.
574	12/17/1997	Route selection methodology doesn't incorporate perception of risk impacts on tourism and property values.
575	01/04/2000	DOE should not transport radioactive waste through Las Vegas.
576	01/04/2000	Opposed to the transportation of HLNW through Clark County.
577	01/04/2000	I am opposed to transporting radioactive waste through Nevada and locating the repository here.

Trust

	Date	**Comments**
578 579 580 581	05/01/1997	Several commenters indicated that the EIS should address the inequities and the "political" and related aspects of the process by which the Yucca Mountain site was elected for study by Congress. Issues raised by the commenters included: (1) siting a repository at Yucca Mountain considering that the original NWPA required selection of a first site west of the Mississippi River and a second site east of the Mississippi River, (2) the validity of the NWPA given that the state was viewed as politically weak and that comparative evaluations among sites are not possible, (3) the lack of funding for Nevada's Nuclear Waste Project Office, because the Office is finding scientific problems with the Yucca Mountain site, (4) the perspective that the site is not likely to be found unsuitable because of the large amount of money already spent, and as problems are found at Yucca Mountain the siting guidelines will be revised, and (5) queries as to what other areas/sites have been examined for waste storage.
582	05/01/1997	Commenters expressed general support for the NEPA process, specifically the information distributed to the public, the process for preparing an EIS, and the need to consider the potential for environmental impacts. Some said they would support the project if it proved to be the best option. Others emphasized that the public would never be for the project, but a decision must be made.

EIS001888

ATTACHMENT E

OTHER COMMENTS, LETTERS FROM:
*GREATER LAS VEGAS ASSOCIATION OF REALTORS
*SOUTHERN NEVADA HOME BUILDERS ASSOCIATION
*CLARK COUNTY COMPREHENSIVE PLAN STEERING COMMITTEE
*LAUGHLIN TOWN ADVISORY BOARD
*WINCHESTER TOWN ADVISORY BOARD

EIS001888

Statement by Gary Coles, President of the Greater Las Vegas Association of REALTORS®

A statement of the Greater Las Vegas Association of REALTORS® in opposition to the use of Yucca Mountain as a repository for high-level nuclear waste and the proposed transportation of that waste through Clark County and surrounding areas.

The Greater Las Vegas Association of REALTORS® joins with other government, business and civic organizations in general objection to the use of Yucca Mountain as a nuclear waste site and specific objection to the validity of the Department of Energy's Impact Statement (DEIS) concerning transportation routes of nuclear waste through and around Clark County.

Since its inception in 1947, the Association of REALTORS® has been a prime proponent of private property rights, quality of living, respect of the environment and issues such as education, safety and community planning.

The 1,400 page Department of Energy's Impact Statement contains many sections that can be considered either inadequate or incomplete.

Specifically:

1. Use of 1990 population figures result in gross underestimation of people that may be put at risk by nuclear waste transport.

2. Land use and strategic plans that guide area development have not been considered in the DOE program. Some routes actually dissect large planned developments.

3. There is evidence in other areas of the country that property and business values may be reduced severely just by the designations of nuclear waste routes.

In specific reference to the proposed routes of transportation, present and future homeowners face the problem of:

- The lack of proper equipment and training for the control of spilled or leaked nuclear waste in a community neighborhood.
- Residential/neighborhood panic following the report of a nuclear waste accident near a school where their children attend.
- Effective loss of the use of major arterials because of the congestion caused by slow moving overdimensional vehicles.

Page Two
Continued

- Lack of a federal facility or program to protect or compensate communities and individuals in case of a nuclear waste accident.

In addition to these safety aspects of a nuclear waste incident you also have an economic impact of waste being routed by established residential areas.

- A route near an established neighborhood will immediately devalue the price of the home.

- Projected services for that area such as additional schools, medical and commercial services would be of questionable value.

- Resale value of residences along a nuclear route will plummet.

- Desirability of a home in the Greater Las Vegas valley will drop to a new low.

- Construction of new homes will also drop drastically.

- Businesses that considered Southern Nevada as a possible site for production and employment will reconsider due to the negative perceptions of the area.

- The gaming, tourist and convention interests that employ so many homeowners would see a definite decline in visitors at the perceived risk or report of even a minor nuclear waste accident.

Homeowners are the one stable force in any community, city or county. Homeowners are the tax base; they provide the need of many services, water, power, food, medical home insurance, repair services.

As REALTORS® we are very much aware that if you disrupt the option and opportunity of a family to have their most serious investment in a safe and secure home threatened you will find that the Greater Las Vegas valley area will rapidly become a depressed area.

REALTORS® OPPOSE NUCLEAR WASTE IN NEVADA!

EIS001888

Southern Nevada
Home
Builders Association

2/24/00

Wendy Dixon, EIS Manager
Yucca Mountain Site Characterization Office
Office of Civilian Radioactive Waste Management
U.S. Department of Energy M/S 010
P.O. Box 30307
North Las Vegas, NV 89036-0307

Dear Ms. Dixon:

This letter is a response to the draft Environmental Impact Statement for the proposed nuclear waste repository at Yucca Mountain. The Southern Nevada Home Builders Association consists of 750 member companies involved in the residential building industry and is an affiliate of the National Home Builders Association. These companies employ thousands of Southern Nevada residents and are truly community stakeholders. Our comments will address the industry concerns of nuclear waste transportation and storage within Southern Nevada.

It is clear that while transportation of nuclear waste to Yucca Mountain remains an uncertainty, nuclear power industry executives are fixated on pushing the process forward with little or no concern for the residents of Southern Nevada. This point is displayed by Rod McCullum of the Nuclear Energy Institute when stating the process should move forward recognizing there is an "involuntary risk" in disposing of nuclear waste. The transportation of nuclear waste poses a clear and undeniable risk to the residents and economy of Southern Nevada. Furthermore, such comments undermine and trivialize the very real concerns we have about the impacts on our communities for years to come.

Given Clark County's potential role in the transportation of nuclear waste, adverse impacts to property values and tourism have not been adequately addressed. As demonstrated in New Mexico, perceived risk can lead to a decrease in property values. With that in mind, we can be reasonably assured that additional health consequences or a nuclear waste-related accident along the transportation corridor would have severe ramifications on public health, safety and property values in Southern Nevada. The DEIS does not include current populations figures or future projections along the proposed routes. Without question significant growth along the corridor, in a County that holds 70% of the state's residents, will have very serious implications for future generations of Southern Nevadans.

The population element in the DEIS should also include visitors to our county. More than 32 million tourists annually augment the population of the metro Las Vegas area, situated directly along the proposed truck route. This is not to be overshadowed by the fact that tourism as a whole is the lifeblood of Southern Nevada. The economy of our region and state depends on these visitors, visitors who may choose not to come if nuclear waste is transported through the Las Vegas Valley.

3685 PECOS McLEOD • LAS VEGAS, NEVADA 89121-3805 • (702) 794-0117 • FAX 794-2439

"Those who Belong... Care!"

EIS001888

In the view of many thousands of residents and visitors who use the local roadways, driving alongside shipments of nuclear waste is unacceptable. These routes are essential to both commerce and residents in the valley. Should either highway be compromised by an accident involving the shipment of nuclear waste, impacts to the community would be devastating.

In economic terms, the construction of a repository in our region can only be viewed in a negative light. Job creation at the proposed repository, even at periods of peak employment, is greatly outweighed by the negative impacts of nuclear waste transportation and storage. Additionally, we enjoy very robust economic conditions in the region. Our unemployment figures are some of the lowest in the country and future projections are very positive. Quite simply, any job creation at the proposed repository is easily mitigated by current and future growth in the regional economy.

Many concerns relative to public health have not been adequately investigated. The DOE's projections for latent cancer fatalities are only estimations and cannot provide accurate assessments of the long-term health consequences. And as we know, the aftereffects of a nuclear waste-related accident would have far-reaching impacts for the current and future citizens of Southern Nevada.

As home builders, it is imperative that we remain sensitive to the needs and interests of current and future residents of Southern Nevada. Some would say that this effort is made merely to enhance the position of our industry. But it is much more than strategic planning. It is our obligation as community stakeholders and a duty that we hold in very high regard. The time has come for our voices to be heard in this debate. Decisions made today will touch the hearts, minds, and lives of Southern Nevadans for many years to come.

Sincerely,

Irene Porter

Irene Porter
Executive Director

EIS001888

Clark County
Comprehensive Plan Steering Committee

Member Organizations
Clark County Planning Commission
Enterprise Town Advisory Board
Paradise Town Advisory Board
Winchester Town Advisory Board
Sunrise Manor Town Advisory Board
Whitney Town Advisory board
Spring Valley Town Advisory Board
Lone Mountain Citizen Advisory Council
Las Vegas League of Women Voters
Greater Las Vegas Chamber of Commerce
Henderson Chamber of Commerce
North Las Vegas Chamber of Commerce
Las Vegas Board of Realtors
Southern Nevada Homebuilders Association
Commissioner Woodbury - General Public
Commissioner Williams - General Public
Commissioner Gates - General Public
Commissioner Kenny - General Public
Commissioner Malone - General Public
Commissioner Kincaid - General Public
Commissioner Herrera - General Public

Staff
Jon Wardlaw, AICP
Assistant Planning Manager
Kim Bush
Administrative Secretary

January 10, 2000

Clark County
Board of County Commissioners
500 S. Grand Central Parkway, 6th Floor
Las Vegas, NV 89155-1601

Dear Board of County Commissioners;

We, the Clark County Comprehensive Plan Steering Committee, want to express our concern about the inadequacy of the recently released Yucca Mountain Draft Environmental Impact Statement (DEIS). Among other concerns, some of the key items we don't believe are adequately addressed are the following:

- 583 The majority of the transportation options would affect Clark County (Interstate-15, the Beltway, a rail line in the northern part of the Las Vegas Valley and, possibly the Spaghetti Bowl). Despite this, no analyses are performed of potential impacts to our economy and quality of life from these transportation options.

- 584 The NEPA process requires that "reasonable" impacts from the project be recognized. Although Clark County could experience a large number of shipments there is no recognition of potential impacts from these shipments. Potential impacts to our tourist-based economy, for example, are not even considered.

- 585 The Department of Energy was one of the first federal agencies to develop an *Environmental Justice* policy. It is unfortunate, then, that the evaluation of effects on minority, low-income and Native-American groups is totally ignored in the *DEIS*. For example, U.S. 95, a major proposed routing option bisects the Las Vegas Paiute reservation. No statement is made of potential impacts. Other routes through the Las Vegas metropolitan area are adjacent to minority and low-income populations. However, there is no recognition of potential impacts to these populations in the *DEIS*.

In addition, we have receive reports from DOE staff and contractors, and from Clark County staff about the Yucca Mountain program. We support the Clark County Board of Commissioners in their efforts and the detailed comments they will submit.

586 The DEIS does not meet the letter or the spirit of NEPA. It does not provide the information that is needed to be able to assess the real impacts, not only to the citizens of Clark County, but to the nation as a whole. For example, no national transportation routes are suggested - how can an assessment of the environmental impacts be made? Likewise, in Nevada, so many routes and modes of transportation are made - time and resources do not allow an adequate assessment of environmental impacts along the routes.

587 We would strongly suggest that at a minimum, a supplemental document is needed to address the concerns that we have raised. We also know that other people and groups are concerned because of the inadequacy of the document. The spirit of NEPA requires that all environmental impacts be addressed. We are hopeful that DOE can meet that objective, in creating a document that fulfills the spirit and technical challenges of NEPA.

Sincerely,

Michael Dias
Chair
Clark County Comprehensive Plan Steering Committee

CPSC BCC ltr.wpd

Laughlin Town Advisory Board

REGIONAL GOVERNMENT CENTER
101 CIVIC WAY
LAUGHLIN, NV 89029
(702) 298-0828
FAX (702) 298-6132

EIS001888

January 11, 2000

Wendy R. Dixon, EIS Project Manager
Yucca Mountain Site Characterization Office
Office of Civilian Radioactive Waste Management
U.S. Department of Energy
P.O. Box 30307, M/S 010
North Las Vegas, NV 89036-0307

Dear Ms. Dixon:

The Laughlin Town Advisory Board met on November 9, 1999, and voted to voice its numerous concerns regarding the proposed Yucca Mountain nuclear waste storage site and accompanying transportation dangers.

In spite of the opinions of many easterners and a long-standing myth, Nevada is not a wasteland that everyone with unwanted, radioactive and nuclear waste should use as their out-of-sight-out-of mind dump. As the fastest growing state, and with Clark County being the fastest growing county, we have a proven record that spans decades: Southern Nevada is attractive to thousands of new residents monthly and many millions of visitors from around the world annually.

By opening Yucca Mountain and transporting nuclear waste to this site, you not only could adversely affect the groundwater in our state, but our citizens will have to be exposed daily on our highways to slow, escorted transport vehicles that could have and cause accidents. Although the studies and estimates thus far indicate such accidents would likely be rare, it only takes one real disaster to ruin for the rest of our lifetimes the place we call "home."

We realize Yucca Mountain has been the subject of numerous studies and discussions for more than a decade but apparently there have not been honest and forthright answers given to the American people, Congress and, specifically, Nevada citizens by the scientific community and the Department of Energy on the nature and extent of the impacts that Yucca Mountain could have on the long- and short-term.

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Wendy R. Dixon
Yucca Mountain
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Therefore, the Laughlin Town Advisory Board can in no way support the opening of Yucca Mountain as a nuclear waste repository and urge more in-depth study be given to alternatives.

Sincerely,

LAUGHLIN TOWN ADVISORY BOARD

Lorraine Haywood

LORRAINE HAYWOOD
Chair

JAB:/rmr

cc: Laughlin Town Advisory Board members
County Commissioner Bruce Woodbury
Jacquelyne A. Brady, Town Manager
Kevin Smedley, Current Planning
U.S. Senator Harry Reid
U.S. Senator Richard Bryan
U.S. Congressman Jim Gibbons

Winchester Town Advisory Board

The Winchester Town Board meets twice a monthly and these meetings include business owners, students, grandparents, and young families. The topics are numerous dealing from zoning to community to quality of life. We have heard many different views on the subject of Nuclear Waste / Yucca Mountain.

We have reviewed the Environmental Impact Draft Study (EIDS), and have found **many** areas have been completely over looked.

There were no studies or surveys done in the following areas:

588 **Economic Effects** –
Special Taxing Districts & Special Taxes - that are collected from Auto Rental, Trucking, Airport user fees, just to name a few.
Tax Base - over 50 % of our tax base comes from gaming revenues.
Visitor Volume - the reduction of a world wide visitor volume based on a by country by region or state.
Property Taxes and Property Values

589 **Cost Effectiveness**
Existing Storage -versus - the cost of encasement, trucking, roadway repair, etc..

590 **General and Emergency Health and Safety Issues**
At any given time our population can double. If a minor or major accident occurs are the Emergency Medical, Fire and Police more than adequately equipped and trained to handle the situation. Are the Hospitals equipped, adequately staffed, and are there enough rooms to care for injured whether or not our population is inflated?

591 **Faults, Possible Earthquakes, Underground Water**
" The builders of the Titanic believed it was unsinkable, so did those who purchased tickets, so did the press." Now, we know different. Several months ago we experienced an earthquake. It took place at an unnamed fault, unnamed because it was believed by "authorities" in the field to be inactive. Now, we know different.

592 We would ask that you complete the proper research of the above concerns. We also asked that other sites including those already in existence be evaluated.

Sincerely

Kristine Makowsky
Vice Chairperson